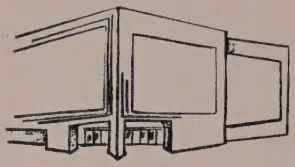

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THE NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY

JOSEPH HYDE PRATT, State Geologist

ECONOMIC PAPER No. 34

THE MINING INDUSTRY

IN

NORTH CAROLINA DURING 1911 AND 1912

BY

JOSEPH HYDE PRATT, State Geologist

RALEIGH
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LETTER OF TRANSMITTAL

CHAPEL HILL, N. C., April 1, 1914.

To His Excellency, HON. LOCKE CRAIG,
Governor of North Carolina.

SIR:—I have the honor to submit herewith, for publication as Economic Paper, No. 34, a report on the Mining Industry of North Carolina for the years 1911-1912. In the collection of the statistics for this report we carried out the arrangement of coöperation with the United States Geological Survey, as hitherto authorized by the State Geological Board.

Yours respectfully,

JOSEPH HYDE PRATT,
State Geologist.

PREFACE

In the following report on the Mining Industry of North Carolina for the years 1911-12 the Survey has tried to give a concise and accurate idea regarding the production of the various minerals in the State and their economic importance. In this connection, there are published, in addition to the general information obtained by this Department, several descriptions of the occurrence of certain minerals that have been prepared by men connected with the United States Geological Survey and the United States Bureau of Mines. Although these special reports have been printed in the United States Government publications, it has been thought best to reproduce them in this annual report, as they are of very great interest to the mining industry of the State, and we have felt that they should be published in such shape that they could be obtained by any who are interested in the mineral production of North Carolina. Many of these reports cover other States than North Carolina, but only that portion relating to this State has been reproduced.

One of the important parts of this report is the collecting and tabulating statistics regarding the mineral production, and this work has been under the direct supervision of Miss H. M. Berry, Statistician to the North Carolina Geological and Economic Survey. This requires a great deal of detailed work in editing the statistic cards and in preparing the elaborate tables which are given in this report. The collecting of the statistics is carried on in coöperation with the United States Geological Survey, and the individual statistics are considered confidential except in those cases where special permission is obtained for publishing them separately.

Joseph Hyde Pratt,

State Geologist.

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Iola Cyanide Mill, Candor, Montgomery County, North Carolina.

MINING INDUSTRY IN NORTH CAROLINA DURING 1911 AND 1912.

By JOSEPH HYDE PRATT, State Geologist.

INTRODUCTION.*

During the years 1911 and 1912, covered by this report, there has been a marked increase in the production of minerals in North Carolina. This increase is due to those minerals which constitute North Carolina's chief mineral resources, and which offer the best possibilities for investment, namely, building stones, clay products, gold, and mica. While there has been a very large increase in the production of clay products and building stones, yet the most marked increase is in the production of gold and silver. This is due to the more systematic mining and exploitation that has been carried on in connection with the production of these metals. The reopening of the famous Silver Hill mine resulted in the production of lead and zinc. There was very little activity in the copper districts, owing principally to the comparatively low prices of copper. There was but little development work or actual mining in any of the districts.

The production of monazite began to decrease very rapidly in the year 1907, and is not now being produced at all in the State. This is due to the low price at which monazite is imported, and more particularly the price at which thorium nitrate is imported.

The productions of iron, mica, and kaolin have steadily increased during the past five years.

On the whole, it may be said the mining and quarrying industries of the State are in a more prosperous and flourishing condition than ever before in the history of the State; and that the results accomplished should mean still greater activity in mining and a larger investment in the mineral resources of the State.

The following might be mentioned as favorable opportunities for the investment of capital in the mineral resources and products manufactured from them in this State:

Opening of stone quarries for the production of crushed rock for concrete.

Development of granite quarries suitable for building purposes.

Siliceous gold ores.

*The statistics given in this report, with the exception of gold and silver, lead and zinc, were collected in coöperation with the United States Geological Survey.

Development of the magnetic iron ores of Ashe County, as a railroad is now being built into this field, which brings deposits in close touch with the coal fields of Virginia.

Development of talc and soapstone deposits in the same county.

Pottery plants for utilizing the kaolin and feldspar produced in the State.

Up-to-date brick plants in many sections of the State.

Erection of a central plant and mill for washing kaolin and for crushing and grinding feldspar.

In 1911 the total value of the mineral production in North Carolina was $2,933,878, as compared with $2,848,446 in 1910. In 1912 there was a much greater increase in the annual production, and it was valued at $3,514,892. There is given in the table below the value of the various minerals produced in North Carolina for the years 1908-1912, inclusive, and shows very strikingly the decided increase which has taken place in the mineral production each year since the financial depression of 1907:

MINERAL PRODUCTION OF NORTH CAROLINA DURING 1908-1912, INCLUSIVE.

Mineral.	1908.	1909.	1910.	1911.	1912.
Gold	$ 97,495	$ 43,075	$ 68,586		$ 166,014
Silver	668	324	4,888	$ 71,074	2,985
Copper	2,560	29,186	17,845		10,521
Lead					25,694
Zinc					
Iron	76,877	107,013	114,237	149,369	186,264
Abrasives: Garnet	4,052	9,188	7,981	9,773	
Abrasives: Millstone					10,625
Mica: Sheet	114,540	122,246	193,223	187,496	219,874
Mica: Scrap	13,330	26,178	37,237	29,579	36,675
Precious stones	570	479	700	10,735	5,655
Monazite	37,224	46,928	10,104		
Zircon		250		*	
Talc and pyrophyllite	51,443	77,983	69,805	57,101	63,304
Mineral waters	27,163	20,558	21,389	31,108	22,385
Stone	824,927	850,807	920,027	840,071	1,090,831
Sand and gravel	2,070	13,358	13,406	93,336	38,487
Clay products†	944,317	1,302,611	1,223,704	1,410,736	1,605,474
Miscellaneous	‡109,880	‡133,642	‡145,314	‡19,500	§30,104
Totals	$2,307,116	$2,783,826	$2,848,446	$2,933,878	$ 3,514,892

*Included under Miscellaneous. †Includes Kaolin.
‡Includes production of barytes, zircon, coal, feldspar, graphite, and quartz.
§Includes quartz, barytes, feldspar, tin, coal, and ores of rare metals.

There is given in the following pages a discussion of the minerals and ores that have been mined or investigated in North Carolina during 1911 and 1912, which are taken up in the following order: Gold and silver; copper; lead and zinc; iron; tin; manganese; nickel; pyrite;

abrasive materials (corundum, garnet, and millstones); mica; quartz; barytes; monazite; zircon; talc and pyrophyllite; precious stones; mineral waters; coal; graphite; asbestos; rare metals; stone; sand and gravel; sand-lime brick; feldspar and kaolin; clay and clay products.

GOLD AND SILVER.

During 1911 and 1912 there has been a renewed interest aroused in gold mining in North Carolina, due particularly to the finding of pay ore in depth in some of the ore mines, and partly to the large increase in the production from mines which have been working for the past few years. The result has been that a great many of the old mines have been reopened and put in operation. Another reason for this reawakened interest is that capital generally is becoming interested in the development of the Southern States to quite a large extent in various industries, and some of this has turned toward the development of gold properties. On account of the interest that has been aroused in the gold mines in the State and the many inquiries which are being received at the Survey office regarding these properties, there is given in this report a more detailed report on gold mining than has been given for several years.

The greater portion of the gold produced in North Carolina is obtained from deep mining, and smaller amounts from placer deposits.

Two changes are to be noted in the method of treating gold ores in North Carolina during the past two years: one is the adoption of crushers and rolls in place of stamps, and the other is the introduction of the "all-slime Cyanide Process." These are described in detail beyond.

In 1912 North Carolina produced over two-thirds of the gold output of the Eastern States, this amounting in value to $166,014, an increase of $95,732 over the production in 1911 of $70,282. This production in 1912 was obtained from 22 placer properties which reported 423.38 fine ounces of gold; from deep mines which gave a total output of 7,321.95 fine ounces; from copper ores which gave 43.68 fine ounces; and from lead-zinc-silver ores, which gave 241.92 fine ounces of gold. The ore treated from the deep mines amounted to 14,358 short tons of siliceous ore, which had an average precious metal recovery value of $10.62 per ton.

The gold obtained from North Carolina is very fine, carrying but a very small amount of silver. Nearly all of the silver credited to North Carolina comes from copper ores. This accounts for the large percentage increase of the silver production of 4,854 ounces in 1912, as

compared with the production of 943 ounces in 1911, as there was a considerable production of copper in 1912, and none in 1911.

There is given a brief résumé by counties of the condition of the gold and silver mining industries in these counties.

Burke County: The production of gold from Burke County was obtained from small placer operations near Bridgewater and Burningtown. In 1911 the production was valued at $714, with a small amount of silver; in 1912 the production was $1,000 of gold and $4 of silver.

Formerly quite a little gold was obtained in Burke County as a by-product in placer mining for monazite; but during the past two or three years the discontinuance of monazite mining has decreased the gold production.

The most noted area in Burke County is the J. C. Mills property at Burningtown, which covers a large area on both sides of Silver Creek, and includes the eastern half of Pilot Mountain. More or less work has been done on this property nearly every year since it was discovered in 1828, but there still remains considerable virgin ground, and a great deal of the tailings left from previous mining will undoubtedly pay if rewashed. One thing that has handicapped more extensive mining in this district has been the lack of sufficient water for mining purposes. There has been but very little systematic development of the property; but, from what is known of the occurrence of the gold in that section, it is believed that systematic mining on a large scale could be carried on profitably. It would need, however, the installation of a plant suitable for mining vein ore as well as placer, and of treating both types of deposit.

Other properties in Burke County are the Hancock Mine, which is a placer digging situated on the northeast slope of Hill's Knob; the Carolina Queen Mine, which is situated on the northeastern slope of Hill's Knob on Hall's Creek; the placer ground on Hall's Creek is practically exhausted; the Hodge property consists of some placer ground along Silver Creek, an adjoining bottom about three and a half miles north of Pilot Mountain. Some attempts have also been made to dredge the sands and gravels of the Catawba River. Thus far this has not met with any commercial success.

A dredge was built in 1912 by the Catawba Dredging Company, but it is reported that this now has gone into the hands of a receiver.

Another company which is doing some developing and prospecting work is the Niebelung Gold Mining Company, which is the successor of the Blue Ridge Mining Company, and which is exploiting the Blue Ridge Mine.

Cabarrus County: The production of gold in Cabarrus County is obtained chiefly from the operation of small placer deposits or the reworking of old dumps. Such operations were conducted at the Gannon Mine, the Saunders Mine, the Reed Mine, the old dump of the Phœnix, and the old concentrates at the McMakin. The result of this work in 1911 was a production of gold valued at $1;567, and in 1912 of $475.

It is expected that the Pioneer Mills Gold Mine, C. McDonald, agent, Concord, N. C., will be developed in the near future.

Caldwell County: There was no recorded production of gold from this county in 1911 or 1912. A certain amount of prospecting and development work was done at several localities, as the Corpening Mine, owned by Mr. J. A. Dula of Lenoir, which was leased to Baltimore parties; the Packe's Hill Mine, two and a half miles northwest of Hartland, and owned by D. W. Lloyd; the Baker Mine, situated on the western slope of Davis Mountain, near the Jones River, and owned by Isidore Wallace of Statesville. Some prospecting was done on this mine in 1911, but no work in 1912.

The Fleming Mine, owned by J. W. Fleming of Lenoir, is equipped with a stamp mill, boilers, pumps, etc., and was developed to some extent in 1911.

Catawba County: The principal mining operations in this county are confined to the Shuford Mine, which has been described in detail in a previous report.*

This mine was reported "idle" in 1912. There was a small amount of gold obtained from the sluicing of gravels on several streams. In 1911 the value of gold produced was $7,148; in 1912, however, owing to the shutting down of the Shuford Mine, the gold production was only $135.

Cherokee County: In 1912 sluicing of the gravels on the middle branch of Tatham's Creek near Andrews was continued for about three months, which resulted in a small output of gold nuggets. With the death of the owner, however, work was suspended. No work was done so far as could be learned in 1912.

Cleveland County: While monazite was being mined extensively in Cleveland County, there was always a small amount of gold reported, which was obtained as a by-product. In 1911 the old gold mine at Kings Mountain was reopened and a small production of gold obtained during the development work. A mill was erected to treat the ore, but as far as could be learned there was no production during

*Economic Paper, No. 14, p. 37.

1912. This property is being operated by the Kings Mountain Gold Mining Company, 219 Mint Arcade, Philadelphia, Pa.

Davidson County: The Silver Hill Mine is one of the famous mines of the Cid District, Davidson County, and has been the producer of wonderfully rich silver-lead ore during the past. Its production of native silver is especially noted, as well as the beautiful series of associated minerals found with it, such as pyromorphite, cerussite, calamine, etc. The mine has been worked at intervals for a period of seventy-five years, and was a rather constant producer until the unaltered sulphides were encountered at depth. The ore is complex, consisting of lead, zinc, copper, and iron sulphides. With modern methods, however, of extracting the metals from such ores, this property should again become a good producer.

In 1911 the mine again became a producer, and also in 1912. The mine is opened by a main shaft nearly 725 feet deep. The plant for treating the ore is a small one consisting of five stamps, two 25-ton Deister slime tables, and three double hopper classifiers, the development work being carried on in order, if possible, to locate a new body of ore between the main mine and the north mine. A special detailed geological study has been made of the region around the Silver Hill Mine, and this is given in Bulletin No. 22, on the Cid Mining District.

There was no work reported on the property of the Hercules Gold and Copper Company, near Cid, or at the Lafflin Mine belonging to the Empire Mining Company.

A car-load of slag and refuse from the old smelter of the Conrad Hill Mine was shipped to Perth Amboy, N. J., as described by Mr. J. P. Laban, who controls the property. He reports that the car-load netted 4,466 pounds of copper, 19.08 ounces of gold, and 39.9 ounces of silver.

Franklin County: The Portis Mining Company operated the Portis Mine near Wood on Fishing Creek in 1911. During this year a new plant was installed, which had a capacity of 100 cubic yards per day. "The excavating machinery consists of a radial cableway of 800 feet span, arranged so as to excavate the entire area of a circle 1,600 feet in diameter. The digging is done with a scraper bucket, operated entirely by the engineer. Improved washing machinery has been designed and installed for breaking up the clay deposits and separating the fine gold from the clay. A pumping plant has been put in in connection with the new plant, and is situated one mile away on Shocco Creek and delivers 1,000 gallons per minute from a 10-inch pipe line one

mile in length. This plant is of a new type for handling placer deposits, and it is expected that the whole cost of operation will not exceed 6 cents per cubic yard."

GUILFORD COUNTY: A very small output of placer gold was reported from Guilford County in 1912. An interesting find was made on a farm owned by A. Horwitz, about five miles southeast of Greensboro. A sample of brownish quartz ore, taken from a hole 7 feet deep, was assayed by Mr. Frank P. Drane of Charlotte, and gave 1.4 ounces gold and .10 ounce silver to the ton.

The Gardner Hill Mine, seven miles southeast of Greensboro, has recently changed hands, and it is expected that it will be developed by the North Carolina Partridge Smelter Company, which has erected a smelter at Charlotte.

HALIFAX COUNTY: There was a small amount of gold produced in Halifax County both during 1911 and 1912.

HENDERSON COUNTY: While there was no production of gold reported from Henderson County during the past two years, considerable interest has been aroused in the report that the old Boylston Mine is to be reopened. The gold of this mine occurs very finely divided, so that great difficulty has been experienced in saving it on plates. It is understood that those who are now contemplating the operation of this property expect to treat the gold by Cyanide Process.

JACKSON COUNTY: There was no production of gold ores in Jackson County, but a certain amount of gold was obtained as by-products from the copper ores mined at Cullowhee in 1912.

LEE COUNTY: The Sanford Gold Mining Company is developing a property near Sanford, Lee County. There has yet, however, no production of gold been made.

MCDOWELL COUNTY: A small amount of placer gold was obtained near Dysartville and Vine Mountain in this county during 1911. No production was reported in 1912.

MECKLENBURG COUNTY: Although there are a good many deep mines in Mecklenburg County which were formerly operated and added considerably to the gold production of North Carolina, these produced but very little gold during the past two years. The small amount of gold that is credited to Mecklenburg County was obtained from dredging the sands and gravels of the Catawba River and from placer deposits. The gold dredge belonging to the Piedmont Placer Mining Company was operated on the Catawba River near Charlotte in 1912, but not for gold. It was used in obtaining sand and gravel for use in the concrete construction of a bridge across the river.

Several mines are being investigated, and, with the completion of the smelter at Charlotte, they will probably be reopened and further developed. These mines are: The Rudisil Mine, belonging to the Rudisil Company, 720 Ocean Avenue, Brooklyn, New York, W. H. Chandler, Secretary; the Surface Hill Mine, belonging to the Surface Hill Mining and Milling Company, Charlotte, N. C., R. Burge, general manager (this mine is being equipped with machinery); the Moore Mine, R. G. Wentz, Matthews, N. C.; the Grier Mine, owned by F. W. Woolworth, Stewart Building, New York City; and the Yellow Dog Mine, owned by Dr. Charles L. Alexander, Charlotte, N. C.

Montgomery County: The production of gold and silver in 1911 was $55,780 in gold and $404 in silver. In 1912 this output had increased to $149,465 in gold and $1,161 in silver. The largest producer of gold in this county is the Iola Mine. It may be of interest to note that it was in 1912 the largest gold producer east of the Black Hills. The old milling plant of the Iola Mine was destroyed by fire in 1910, and was not rebuilt and put in operation until 1911. In the new mill the "all-sliming" process is used. This is described beyond. The Iola Mine, formerly owned by the Iola Mining and Milling Company, is now owned by the Candor Mines Company, of Candor, N. C.

The old Coggins Mine, which is located one and a half miles north of Eldorado, Montgomery County, was under water in 1910, and a 40-ton Lane slow-speed Chilean mill with amalgamation and concentration equipment was completed in 1911. Considerable ore was mined and treated, and this mine was one of the chief producers of gold in Montgomery County in 1911. A fire, however, destroyed the plant early in 1912, so that there was very little gold produced in that year. The Coggins Mining Company, which owns the property, was reorganized after the fire, and is now known as "The Rich Cog Mining Company." They have erected a new plant, and this mine should become one of the chief gold producers in Montgomery County. A description of this mine is given beyond.

The Montgomery Mine, formerly owned by the Montgomery Mining Company, and now owned by the Uwarra Mining Company, Candor, N. C., did a great deal of development work during 1911 and 1912, and have erected a 50-ton mill, which uses rolls instead of stamps. A description of the mill and process is given beyond. This company has sunk a No. 2 shaft to the 300-foot level, and has opened up 3,000 feet of laterals. There was no production, however, of gold from this mine during the years 1911 and 1912.

The Martha Washington Gold Mining Company of Candor, N. C., are developing and prospecting a property adjoining that of the Uwarra

Mining Company, but as yet have made no production. Their principal work consists of the sinking of a 50-foot inclined shaft.

There are several other prospects that have been developed during the past two years, and several old mines have been producers to a small extent.

The gold in these mines occurs as a siliceous ore, which is described in detail in Bulletins Nos. 21 and 22 of the North Carolina Geological and Economic Survey.

Moore County: A small amount of prospecting work was carried on in Moore County in 1911 and 1912, and a small production of gold was reported.

Nash County: While there was no production of gold reported from Nash County during the past two years, considerable prospecting was carried on in the vicinity of Nashville. The work done did not develop any ore deposits that gave any great promise of being worked profitably.

Polk County: The gold-bearing ores of Polk County seem to be an extension of the South Mountain Region of Burke County, and during 1911 there was a small production of gold from the Double Branch Mine in the southern part of the county, which is owned by the Double Branch Gold Mining Company, Thomas G. Jones, manager, Landrum, S. C. This mine was equipped with stamp mill and amalgamating and concentrating plant.

Randolph County: Although there was considerable prospecting for gold ores in Randolph County during 1911 and 1912, and some development work carried on at several mines, this resulted in only a small output of gold from this county each year. The principal work was done at the Asheboro Mine, two miles south of Asheboro, and owned by the Asheboro Gold Mining Company, Asheboro, N. C. Many months were spent in prospecting, and the location of several promising ore shoots was reported. A small amount of work was done in operating the placer deposits, but as far as could be learned this was not considered profitable. The Davis Mountain or, as it is now called, "The Conroy Mine," was prospected and developed by pits and open cuts in 1911, and in 1912 produced several hundred tons of ore, which were treated in log washers, and in a small tube mill. This prospecting was done by Mr. F. J. Conroy of Webster, N. C.

The Redding Mine, near Cedar Falls, was developed to some extent in 1911, and made a small output of gold. The work was continued for a short time in 1912, but no output was reported. This property is owned by Messrs. A. H. and B. F. Redding, Randleman, N. C.

At the Southern Home Stake Mine, owned by the Southern Home Stake Mining Company, E. W. Lyon, agent, Greensboro, N. C., but a small amount of prospect work was done during 1911. Little or nothing was done in 1912, and no production of gold was reported.

Several placer deposits were operated in a small way during the past two years, and a nominal amount of gold was obtained.

Rowan County: The principal mines in this county were practically inactive during the past two years. There was, however, a small production in 1911, which amounted to $1,301 and in 1912 to $1,585. This gold was obtained from placer deposits on Third Creek; from work on the old tailings of the Gold Hill Mine by hand rockers; and by working the tailings from the McMakin Mine. The greater amount of gold reported was from this latter mine.

Rutherford County: In 1911 there was a very small output of gold, but in 1912 the output amounted to $3,807, and was obtained chiefly from the Biggerstaff placer deposit. The Jones property, owned by John F. Jones of Blacksburg, S. C., which was developed to a slight extent in 1911, reported no operations in 1912.

Stanly County: There was a small amount of gold obtained from Stanly County in 1911 and 1912, which was obtained principally from placer mining or by hydraulicing decomposed vein material. The principal localities where the gold was obtained are in the vicinity of New London at what are known as the "Crowell, Parker, and Henderson mines."

Union County: There was a small output of gold from Union County during the years 1911 and 1912, the output being obtained from the Bonnie Doone and other mines near Indian Trail. A small amount of development work was done on the Wenona, Davis, and Price properties near Matthews. The Wenona Mine is now owned by the Matthews Mining Company, Matthews, N. C.

There was a small amount of development work carried on at the Moore Mine.

The principal development work was at the Howie Mine at Waxhaw, N. C., owned by the Howie Mining Company. A description of this property and the development work done and mill erected is given beyond.

Wilkes County: A small amount of development work was done by the Flint Knob Mining Company at their property near Mount Zion, Wilkes County. No output from this was reported.

Yadkin County: A small production of gold was reported from this county.

PRODUCTION.

In the following table there is given the production of gold and silver by counties in 1911 and 1912, which will illustrate the distribution of gold produced throughout the State:*

Production of Gold and Silver in 1911 and 1912 by Counties.†

County.	1911.			1912.		
	Gold.	Silver.	Total.	Gold.	Silver.	Total.
Burke	$ 714	$ 3	$ 717	$ 1,000	$ 4	$ 1,004
Cabarrus	1,567	2	1,569	475		475
Catawba	7,148	66	7,214	135		135
Cherokee	296	2	298			
Davidson				5,001	1,471	6,472
Franklin	809	2	811	1,226	2	1,228
Gaston				39		39
Guilford				20		20
Halifax				1,225	1	1,226
Jackson				903	323	1,226
McDowell	311	1	312			
Mecklenburg	809	1	810	146		146
Montgomery	55,780	404	56,184	149,465	1,161	150,626
Moore	215		215			
Polk	296	2	298			
Randolph	212	2	214	347	4	351
Rowan	1,301	4	1,305	1,585	7	1,592
Rutherford	66		66	3,807	8	3,815
Stanly				140		140
Union	718	11	729	500	4	504
Yadkin	40		40			
Totals	$ 70,282	$ 500	$ 70,782	$ 166,014	$ 2,985	$ 168,999

*The gold and silver statistics have been obtained partly in coöperation with the United States Geological Survey through the Director of the Mint at Washington, D. C., the United States Assay Office at Charlotte, N. C., and by direct correspondence with the producers by the State Survey.

†Coining value.

The next table gives the value of the gold and silver produced in North Carolina from 1882 to 1912, inclusive.

Gold and Silver Production in North Carolina from 1882 to 1912.†

Year.	Gold.	Silver.	Total.
1882	$ 190,000	$ 25,000	$ 215,000
1883	167,000	3,000	170,000
1884	157,000	3,500	160,500
1885	152,000	3,000	155,000
1886	175,000	3,000	178,000
1887	225,000	5,000	230,000
1888	136,000	3,500	139,500
1889	145,000	3,878	148,878
1890	118,500	7,757	126,257
1891	95,000	6,465	101,465
1892	78,560	12,671	91,231
1893	53,600	17,325	70,925
1894	46,594	455	47,049
1895	54,200	520	54,720
1896	44,300	646	44,946
1897	34,600	388	34,988
1898	84,000	905	84,905
1899	34,500	388	34,888
1900	44,653	15,986	60,639
1901	60,410	34,023	94,433
1902	93,650	30,212	123,862
1903	113,604	16,907	130,511
1904	123,924	19,133	143,057
1905	129,153	20,216	149,369
1906	122,008	30,944	152,952
1907	82,195	14,299	96,494
1908	97,495	668	98,163
1909	43,075	324	43,399
1910	68,586	4,888	73,474
1911	70,282	500	70,782
1912	166,014	2,985	168,999

†Coining value.

DESCRIPTION OF METALLURGICAL PROCESSES AND MINES.

THE IOLA MINE.*

By Claude Hafer.

"According to G. F. Becker, the gold produced in the United States from 1804 to 1825 came from North Carolina, and the total recorded was $110,000. Before 1825, placers were the only source of metal, but in that year Mathias Barringer mined quartz successfully in Montgomery County. So to this county is to be credited the first vein-mining in the South, and here to-day, nearly a century later, is in operation the most successful gold mine and reduction plant on the Atlantic slope.

*Partly reprinted from the "Mining and Scientific Press," May 17, 1913. See also description of Iola Mine in Economic Paper, No. 14, of the North Carolina Geological and Economic Survey.

This mine, the Iola, was discovered in 1900 in a part of the county little prospected previously, and its success gave rise to a mild boom in the Candor district, which resulted in the discovery of other veins that are, or have been, in course of development.

"The district in which the mine lies is near the junction of the Piedmont plateau and the Coastal plain. It is a region of little relief, and as far as mining operations are concerned may be called flat. It is essentially an agricultural country, well timbered and well watered. Railroads give easy access to the coalfields, and hydro-electric power is close at hand. Mining labor is not plentiful, and is paid from $1.25 to $2.50 for a ten-hour shift. The country rock, as far as excavations made to date reveal, is schist thinly laminated for the most part, though graduating into a more massive rock, having the appearance of andesite.

CHARACTER OF ORE.

"The ore deposits in this mine occur (1) as narrow veins, trending northeast and southwest, and dipping steeply to the northwest, conforming generally to the dip and strike of the enclosing schist; (2) as siliceous pyrite zones in the schist; (3) as aggregations of stringers and lenses with unaltered schist between them. The veins have been crossed by dikes of diabase and other basic rock, and are faulted. The Iola vein varies from 1 to 8 feet in width and has been developed from 2,000 feet along its strike by the Iola and Montgomery mines, and to 650 feet on the dip. A parallel vein on the hanging wall side 180 feet distant and a branch vein have also been productive.

"Shortly after the discovery of the vein a mill was put up consisting of three slow-speed, stone Chilean mills and a 10-stamp battery. It was fed by hands, with no rock breaker. The ore was rich and the returns were remarkable for North Carolina, though nearly as much went with the tailings as was caught by the mercury. At one time 69 pounds of amalgam was obtained from an eight-day run. The plant was close to an incline shaft sunk near a stream crossing the property, an ill-chosen position, as the water-soaked schist requires careful timbering to hold any excavation intact. This shaft became unsafe, and a vertical one was started to cut the vein at 250 feet. The mill was moved to higher ground on the opposite side of the branch, where 10 stamps were added. At this time the mine enjoyed great prosperity, and everybody in the neighborhood who could was prospecting. Mining prospects in the Candor field were in great demand among mining promoters. It is doubtful if there has ever been a parallel case in Southern mining history, unless it was at the time of the discovery of the gold-bearing saprolite at Dahlonega, Georgia.

EARLY MILLING EXPERIENCE.

"The next improvement that was made was a cyanide annex, an out-of-door plant on the slope across the branch from the mill, at a higher level. A launder received the pulp from the plates and discharged into a boot of a belt and bucket elevator, that elevated it 35 feet to another launder that discharged into collecting boxes, each holding 8 tons. The boxes were provided with filter bottoms and the sand was partly dried before being loaded into the leaching vats, three in number, of 25 tons capacity each. The slime overflowed at the end of the settling boxes and was led to one of three agitating tanks, 20 feet diameter, with 12-foot staves provided with mechanical stirrers, and connected with the intake of a 4-inch centrifugal pump. As the tank filled, the clear water was decanted, and when a charge of approximately 20 tons was in the tank the pulp was shifted. All of the water was then decanted, and cyanide solution was run on in its place. The charge then received the combined or alternate treatment of compressed air, stirrers, and centrifugal pump. The solutions were precipitated on zinc shavings in two zinc-boxes under cover near-by. The gold slime was treated with sulphuric acid, and smelted in a little wind-furnace in an adjoining building. The plant operated almost continuously with profitable results for four years.

HANDLING THE ORE.

"In the meantime the stamp mill was burned and shortly after reconstructed with improvements, the latter including rock-breaker, ore-bin with belt-elevator from breaker to bin, feeders, and an automatic dump car for delivering the ore from the shaft 150 feet away. This car was an unnecessary refinement for the small tonnage handled, never over 25 tons per twenty-four hours, and unfortunately the car was somewhat erratic in action. At times it would stick in the middle of its flight, or would run to the terminus, double back halfway, and carefully drop its load in the branch. Eventually it gave way to a cable-drawn car that delivered at the top of the ore-bin, thus doing away with the belt-elevator. The mine had now reached a depth of 350 feet and was in hard ore, which cut down the capacity of the stamps. A mill of 40 stamps was built on higher ground, and development commenced on the southwest extension of the vein. An incline shaft was sunk, which is the present working shaft of the mine, now 450 feet deep. A Cornish pump was installed and a 200-horsepower boiler added. The cyanide plant, now in bad condition, was torn down and the best of the material used in its reconstruction in the building formerly occupied

by the stamps. The new mill operated but a short time, dropping 40 stamps, and a little longer with 20, when the mine was placed in the hands of a receiver and sold, which wound up the affairs of the Iola Mining Company.

ANOTHER MILL.

"During its life the mine produced nearly a half million dollars. The new owner, the Candor Mines Company, immediately commenced active development, and ten months after buying the mine started construction on a modern mill. It was a dry-crushing plant and was completed and in operation six and one-half months when destroyed by fire. It was situated on the slope just back of the incline shaft. The ore was brought by a belt-conveyor to a 50-ton bin, from which it was fed by a Challenge feeder to a dryer consisting of a revolving cylinder that received the flame from a fire-box at one extremity. After being dried the ore was elevated 35 feet by a chain-belt elevator to a steel bin that fed a 42-inch Lehigh Fuller mill. This mill was supposed to grind to 200-mesh and was fitted with 30-mesh screens, which were frequently and easily broken, according to the statement of the management, and allowed coarse material to pass. The finished product was collected in a dry-ore bin of 50 tons capacity. This had a hopper bottom, and in turn discharged to a screw-conveyor leading to an elevator that lifted to a pulp tank on top of a 35-foot high Parral vat. The pulp tank was 4 by 5 feet, and had an ordinary rotary agitator mounted in the center. The pulp overflowed into either of the two Parral vats, through a 5-inch pipe. The Parrals were 13 by 35 feet in size, and discharged from the bottom upon a revolving filter. The solutions were precipitated on zinc shavings as in the old plants.

"The plant was not exactly suited to the conditions; wear and tear were excessive and shut-downs frequent. It produced its share of bullion, however, and was lost by fire in December, 1910. The loss was a blessing in disguise, for it led to the construction of the present efficient mill."

This new mill, which is treating the ores from the Iola Mine, uses the "all-slime process." A description of the Iola Cyanide Mill, by Percy E. Barbour, is given below:

IOLA CYANIDE MILL, CANDOR, N. C.*

By Percy E. Barbour.

"It is a far cry to the time when North Carolina was the first gold-producing State of the Union, yet it is a cherished boast of some

*Reprinted from the Engineering and Mining Journal, Vol. 94, No. 11, 1912. The photographs were not used in the original article.

North Carolinians. When, three years ago, a well-known New York mining capitalist started the financing of a gold mine in this State, his friends said it sounded about as attractive as a banana plantation in Butte. The result, however, is a mine which ships between 40 and 50 pounds of gold bullion semimonthly to the mint from a new mill, which is not only modern in every detail, including the latest types of machinery in every department, but which has the distinction of having the heaviest stamps in the United States.

"Through the courtesy of William F. Mack, the manager, and Arthur B. Parsons, the superintendent, I am glad to be able to furnish some interesting details of this mill and to state the remarkably low milling costs, which would be a credit to a modern mill in a district where the labor is much more efficient than it is here in the cotton country.

EARLY HISTORY.

"The Iola Mine and mill, operated as the Candor Mines Company, are situated about three miles from Candor, Montgomery County, in the south-central part of North Carolina. The surrounding country is an agricultural one, where corn and cotton thrive and on some plantations are raised scientifically on an extensive scale; where large peach orchards ship car-loads daily; where negro and white labor work together harmoniously, and almost equally, when they are not working on the crops; and where the scarcity of labor in general is appalling.

"The early history of the Iola was much like the early history of a Western mine in every way, as the variety of shafts, old stone Chile mills, and other mill and mining machinery on the company's scrap heap all testify. The mine was named in honor of the lady who furnished funds for the early efforts of the project, and who bore the euphonious name of Iola Oyster. The last touch of Western realism is added to this mining district in the cotton belt by noting the small Macedonian graveyard, near the mine, said to contain nineteen killed in fair fight or murdered, which makes even Pioche look to its laurels.

ORE WASHED AND SORTED.

"The present mill has been in operation continuously since its completion, in August, 1911. Sixty-two tons of ore per day are hoisted and dumped from an inclined skip over a 1¾-inch grizzly at the top of the headframe. The undersize drops to a bin in the lower portion of the headframe structure. The oversize is washed on a picking floor at the foot of the grizzly by negroes who learn to do it so dextrously, with buckets of water as the ore falls from the skip, that no delay is occa-

sioned and the rock is cleaned so that about 6 tons of waste can be picked out by hand. The ore is then crushed to 1¾ inches in a 15 x 9-inch Blake crusher. The crushed ore drops into the bin with the undersize through the grizzly, from which bin it feeds to an 18-inch belt conveyor. This conveyor belt, 80 feet long on centers, and inclined 22°, is also the picking belt. At the lower end, a fine water spray cleans the ore again and enables the pickers, seated along the belt, to pick out about 6 tons more of the slate. The elevator discharges into a 100-ton flat-bottom bin. Thus to get the 50 tons of ore into the mill bin, 62 tons are hoisted from the mine. As a matter of fact, if there were sufficient reliable labor, 5 tons more waste could be picked from the 50 tons which are now fed to the stamps through suspended Challenge feeders.

"Underground sorting is unsatisfactory for several reasons. The vein is narrow, averaging about 24 inches, and is frozen to both walls, which are greenish-gray slate. The mine is very wet and the ore is so muddy that it is impossible to sort it satisfactorily underground, and owing to the pieces of slate being frozen to the quartz, crushing has to be done before the final sorting, which latter has to be under the eye of the mill boss or the waste becomes low-grade ore.

"There are two kinds of ore treated, which require radically different treatment of themselves, but cannot be mined and treated separately under local conditions, and therefore have to be mixed just as they come from the stopes. The ore from the upper levels is oxidized and the accompanying waste is a soft clayey brown slate. In the lower levels the ore is a very tough, hard clay quartz with a pearly luster, and the country rock to which the vein is frozen is a tough gray slate. The unavoidable mixing of this ore as it happens to come out of the mine complicates the treatment problem, and more, also, the purely mechanical manipulation of the machinery adjustments.

THE 1,750-POUND STAMPS CRUSH FROM 10 TO 12 TONS PER DAY.

"The battery has five 1,750-pound Allis-Chalmers stamps which have a 7 to 7½-inch drop and make 107 drops per minute. The weight of the stamps is distributed as follows: Stem, 4 inches by 15 feet, 635 pounds; tappet 215-pound boss head, 650 pounds; shoes 9¼ x 14 inches, 250 pounds. The cam shaft is 7 inches in diameter. The mortar box is of the narrow El Oro type and weighs 10,500 pounds. The boss heads extend above the mortar, which has no housing above the screen frame.

"The original set of chrome-steel shoes and dies crushed 4,000 tons of ore. A new set of chrome-steel shoes was put on, and dies, cast at

a local foundry from a mixture of old chrome-steel dies and common pig iron, were used. These dies were hard enough, but were brittle and did not wear out the new set of shoes, and were replaced with all cast-iron dies, also cast locally. The second set of shoes now being worn out is being replaced, and the cast-iron dies, while not worn out, are being replaced with a set of chrome-steel, as at first used. The cost per pound of locally made dies was considerably less, but the cost per ton of ore crushed was approximately the same as when the chrome-steel was used.

"The battery screen originally used was 4-mesh. This screen was found to be entirely too coarse for the capacity of the 4 x 20-foot tube mill, and a Tyler "ton-cap" equivalent to 8-mesh went to the other extreme and failed to load the mill to capacity. At present a double-crimped Tyler screen, with openings one-sixth of an inch, wire 0.120-inch diameter, is being used. The ratio of solution to ore is approximately 6:1. Under these conditions the capacity of the stamps per 24 hours when crushing hard ore along averages 10.5 tons, which is rather low for such heavy stamps. The extremely tough character of the ore is the only explanation. During the month of June, just passed, when 15 per cent of the ore came from the upper workings of the mine, the duty increased to 11.9 tons. While the mine does not produce in excess of the capacity of the mill, 50 tons, and there is accordingly no necessity for increased capacity at the present time, there is no doubt that a 5 x 22-foot tube mill, allowing a 4-mesh battery screen, a larger solution ratio, and closer feeding, would make possible a stamp duty of 15 to 16 tons, and would result in more economical operation.

BATTERY CONSTRUCTION.

"The mortar block is a concrete monolith reinforced with steel rods. It has a tunnel through it into which all holding-down bolts extend; the latter can, therefore, be replaced if necessary without moving the mortar box. There are eight 2-inch bolts for the mortar box and eight of the same size for the shoes for the battery posts. The cross-section of the mortar block is unusual and would seem to be weak structurally at the foot of the batter across the short dimension to the bolt tunnel, but the block has stood a year's pounding of the heavy stamps, which seems to allay criticism. The concrete mixture for the block was 1-2-4. A rubber pad, ¼ inch thick, is used between the block and the base of the mortar box.

"At the end of 11 months operations not a single stem nor tappet nor boss head had been broken. The only breakage about the battery

was a 7-inch camshaft, which gave out after eight months use, due chiefly to a flaw in the material. One cam was broken in removing it from the shaft, but other than this no cams have been broken. A scheme is being tried to damp the vibration of the free end of the camshaft by means of a lever of oak bearing upon the shaft with the free end held down by means of an old spiral crusher-spring. This does away with most of the vibration, and is expected to increase the life of the shaft, as well as the bearings and the battery posts.

REGRINDING THE BATTERY PULP.

"The strength of the mill solution averages 1.3 pounds KCN per ton and the protective alkalinity is 0.6 pound per ton in terms of CaO. The battery pulp is elevated by a 12-inch bucket elevator, with special extra-heavy grit-proof bearings, designed by Bernard MacDonald, to a standard double-rake Dorr classifier. Owing to the hard and tough character of this ore, the slime is always granular, even when it passes 200 mesh (it is never colloidal), and it settles quickly and compactly. Therefore it has been found necessary, in order to obtain a comparatively clean sand for the tube-mill feed, to supplement the spray pipes in the bottom of the classifier with an additional pipe put in above the rakes. The Dorr classifier overflow goes to a Dorr thickener and the classifier discharge drops directly into the feed hopper of a spirally fed 4 x 20-foot Allis-Chalmers tube mill.

"The tube-mill lining is of the Montana Tonopah cast-iron ribbed type. The first set of liners at the head end wore entirely through in eight months, which gives an idea of the abrasive character of the ore. This mill makes 31 r.p.m. The best Danish pebbles are used, which cost between $18 and $19 per ton at the mill. The pebble consumption for the first four months of this year averaged 3.45 pounds per ton of ore crushed. The sand from the Dorr classifier contains 29 per cent solution, and 10 to 11 per cent more is added to give the tube-mill pulp 39 to 40 per cent moisture.

"The tube-mill product is returned to the Dorr classifier by a 6 x 48-inch Frenier sand pump operating against a vertical head of 12 feet. The pump to date has run without any trouble and without any repairs other than the renewal of a pinion and a packing joint.

TREATMENT OF THE PULP.

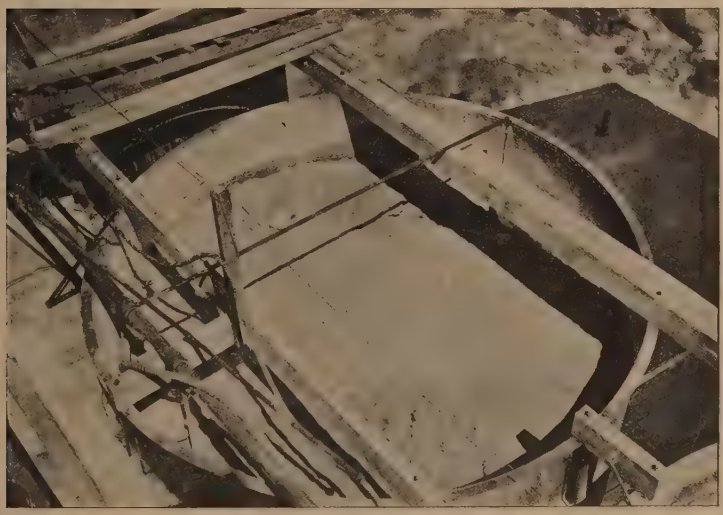
"The overflow from the classifier goes to a steel tank 18 feet in diameter by 8 feet deep, equipped with a Dorr continuous thickener. This thickener is not allowed to discharge continuously, but is drawn off at

intervals of 30 minutes. Then only the thick pulp is withdrawn, fresh circulating solution being added to bring the specific gravity down to about 1.38, the most satisfactory consistence of pulp for agitation here. The pulp discharges through a 12-mesh screen-bottomed tray into a boot of a second bucket elevator. This screen catches nearly a bushel basket full of fragments of wood, which get into the ore in spite of the ore pickers, who should remove such material. This second elevator, similar to the first, carries the pulp to the top of the No. 1 Parral tank. At the boot of the elevator additional lime is added in the form of an emulsion at the rate of 0.5 to 2 pounds per ton, depending upon whether the ore comes from the bottom of the mine or the softer oxidized workings nearer the top. This pulp is discharged into the first Parral tank through a cone, made from an old cone classifier, which has a pipe extending 5 feet below the surface of the contents of the tank. This is done to make the fresh pulp go into the cycle and to prevent any chance of short-circuiting. Fresh cyanide is introduced into the system at this point, being placed on a screen in the bottom of the cone, where it is dissolved by the pulp splashing over it. The cyanide is added every four hours at the rate of about 0.5 pound per ton of dry slime.

"There are three steel Parral tanks, each 13 feet diameter by 29 feet high, with a capacity of 55 tons of dry slime in pulp of the average consistence. The first two tanks are arranged for continuous agitation, and the pulp, therefore, gets an agitation treatment of more than 48 hours before it goes into the third tank, which was originally a Parral, but which has since been changed. The air-lift pipe in this third tank has been cut off one-third the way up from the bottom because this tank acts as a storage tank for the slime filter, which runs only during the day shift, being full in the morning and below the top of the air-lift pipe at night. The pulp, therefore, gets further agitation in this tank, making the total time of agitation equivalent to about 52 hours. However, 90 per cent of the total extraction takes place in the first tank. These Parral tanks are the usual type, with the two air-lifts near the circumference of the tank with their discharge pointed away from the diameter. (See Plate II, A.) These tanks each have a false bottom, shaped like a peaked roof, made of wood. They are arranged so that either can be cut out and the contents filtered.

"A third Parral tank, which serves the dual purpose of an agitation and a storage tank, went through an interesting change from its original form. Inasmuch as the filter is operated only during the day shift, this storage tank is during the night accumulating the slimes crushed during that shift and is slowly filling; the reverse takes place during the day

A. Top of Parral Tank, showing agitation current, Iola Mine.



B. Kelly Filter Press, Iola Mine.

when the tank is being slowly emptied. Originally the tank was equipped with two air-lift pipes, similar to those in the other two tanks, except that the top tee was only about one-third the way up the tank. The discharge pipe to the filter was in the center of the bottom of the tank, so that no false bottom could be put in. The result was that the sand packed around this discharge and caused much trouble in keeping the pipe line to the filter open. To obviate this, one of the lift pipes was put over the center of the tank and the other lift pipe disconnected, with results which justified making this arrangement permanent. The slime has naturally packed high along the circumference of the tank, and, sloping downward toward the center, has built up a nearly perfect inverted conical bottom, so that to all intents and purposes it is now operating as a Pachuca tank. One would hardly look in the field of agitation tanks for an exposition of a Darwinian theory, but this seems to be clearly an example of "reversion to type."

KELLY FILTER USED.

"The separation of the slime and pregnant solution is effected in a Kelly pressure filter (see Plate II, B), size No. 1 B, which easily handles the total tonnage in less than 12 hours. The cycle of operation is: Filling press, 2 minutes; forming cake, 3 to 6 minutes, depending upon condition of leaves; returning excess pulp, 2 minutes; filling with wash pulp, 2 minutes; filling with wash water, 2 minutes; washing, 1½ to 3 minutes; returning wash and drying, 3 minutes; discharging, 12 minutes; total length of cycle, 25 to 30 minutes.

"The filter treats 2.2 tons per charge. The dissolved gold in the tailing varies from 2 to 15 cents, and averages about 7 cents per ton. A solution wash was tried, but the additional time and labor required did not justify the slight additional saving of dissolved gold, so that water is the only wash used at present. The tailing discharged from the filter leaves contains about 20 per cent moisture.

DISINTEGRATION OF FILTER CAKE.

"Built, as found necessary with this plant, on almost level ground, the problem of disposing of the tailing gave some trouble. There is a fair supply of water available, but not enough to carry the tailing through the long wooden launders with only a slight grade until the tough cake is completely broken up. At first this breaking up was accomplished by a real 'down South hoeing nigger,' who worked in the hopper with a hoe, but this was an unsatisfactory combination. A cake disintegrator was devised, consisting of an oak log stuck full of wooden pegs arranged

at right angles to the flow of the tailing and revolved 70 times per minute by belt and pulley. This disintegrator is at the very mouth of the discharge hopper and revolves so that the pegs tend to lift the cake up and carry it over the top of the log. The disintegrator is housed in to prevent splashing. It is an extremely simple, almost crude device, but it works perfectly and saves the labor of one man per day with an inconsiderable expenditure of power. Since the installation of this device the work of sluicing has fallen to the solution man, who is able with a fire hose and a good head of water to discharge the cake from the filter leaves in 3 to 4 minutes, the disintegrator doing the rest. The total water used in flushing away this tailing is about 2 tons per ton of dry slime.

"Every twenty to twenty-five days the filter leaves are washed in a 0.5 per cent HCL solution. They are not treated in the filter drum, as the Kelly Company recommends, but are put in a vat and the solution is forced through them in the same direction as the water, which forces the cake off the leaves. This treatment continues 24 hours. Another reason the leaves are treated outside the filter drum is because a good scrubbing has been found to put the leaves in much better condition for being returned to service. Duplicate sets are kept on hand, and it takes less than an hour to change a set.

"The pulp and the wash water are handled wholly by montejus, no pumps with moving parts being employed in connection with the filter. The mill which antedated this one, which was burned, had a revolving-drum continuous vacuum filter, but the results were unsatisfactory, due to the fact that the ore makes no colloidal slimes. As before stated, when ground to 200 mesh, the product is all distinctly granular, and this product not only did not make a good cake despite all efforts, but owing to the rapid settling of the granular slimes, the tank in which the drum revolved would build up with this settled slime, so that every week it was necessary to shut down and sluice out this tank and lose the entire contents. Several air jets for agitating the pulp in the tank were tried without overcoming the difficulty. The management point to this as a striking example of the superiority of the pressure filter over the vacuum filter for this particular ore.

PRECIPITATION BY ZINC SHAVINGS.

"The pregnant solution from the filtered slime goes to a gold tank, from which it is pumped to a clarifying tank, which has a filter bottom made of wooden slats supporting cocoa matting, the space between the slats being filled with gravel containing pebbles not over ½ inch diameter. On the cocoa matting is 3 inches of fine sand. The top of this

sand layer has to be cleaned off every two weeks and the entire layer renewed every two months. The solution is handled to this tank by a 4-inch Morris centrifugal pump.

"From the gold-filter tank the solution flows by gravity to three 6-compartment zinc boxes, 24 x 36 x 20 inches. Only four compartments of the six are packed. The zinc shavings, cut at the mill in an ordinary zinc lathe, grade 250 per inch and are made up into skeins 2 feet long and as large around as a man's arm. These skeins are laid in the boxes with alternating layers crossing each other cobweb fashion.

SEMIMONTHLY CLEAN-UP.

"Clean-ups are made twice per month, during which the small quantity of short zinc is treated with sulphuric acid, this procedure resulting in a cleaner bullion by excluding a portion of the zinc. The precipitate which passes a 30-mesh screen goes to a clean-up tank and is pumped by a Deane 2 x 3-inch triplex pump to an 18 x 18-inch Shriver filter press. The acid-treated material is put through the press separately. The entire precipitate is then mixed, dried, and melted down in an iron-muffle furnace, using coke for fuel. The flux used consists of 25 parts borax, 15 soda, 15 sand, and 7 each of niter and slag. The slag from the melting is crushed, hand-jigged, and shipped to the smelter. The bullion assays 718 fine ounces in gold and 225 in silver, and is shipped either to the United States Assay Office at Charlotte or to the mint at Philadelphia.

COST OF OPERATION.

"The labor in this section is a source of great annoyance, due to the irregularity of attendance of employees, which also makes for inefficiency. The labor required to operate this mill consists of one millman at $2.50, one solution man at $1.85, one mill helper at $1.65, on each of the two 12-hour shifts, and one filter man at $2 on the day shift only. These men operate and keep up all mill repairs, making the total labor cost $14 per day.

"The treatment cost per ton of ore is $1.64, divided as shown in the table.

Treatment Costs at Iola Mill.

	Per Ton Ore Milled.
MILLING.	
Power	$ 0.577
Crushing and conveying	0.129
Stamping	0.061
Elevating	0.038
Classifying and thickening	0.048
Tube milling	0.041
Mill engine	0.015
General charges	0.096
Total milling	$ 1.005
CYANIDING.	
Power	0.115
Cyaniding	0.190
Precipitating and refining	0.081
Filtering	0.085
Assaying	0.095
General charges	0.069
Total cyaniding	$ 0.635
Total milling and cyaniding	$ 1.64

"The mill heads averaged for a three months period $12.921 per ton, and the tailing $0.552 per ton, showing an extraction of 95.7 per cent. The consumption of chemicals and pebbles for four months of this year is shown in the table.

Consumption of Material.

	Lb. Per Ton Ore Milled.
Cyanide	$ 0.5487
Zinc	0.4600
Lime	3.7425
Pebbles	3.4500

NEW MILLING PROCESS FOR TREATING NORTH CAROLINA SILICEOUS GOLD ORES.

A new milling process of considerable interest has recently been installed at the Montgomery Mine owned by the Uwarra Mining Company, of which Mr. Percy E. Barbour is manager and also general de-

General View of Surface Plant, showing new mill of the Uwarra Mining Company, Montgomery County.

signer of the mill, which consists of the substitution of crushers and rolls for the stamps ordinarily used. A description of this property and mill has been prepared by Mr. Barbour.

THE UWARRA MINING COMPANY.

By Percy E. Barbour.

The Uwarra Mining Company owns and is operating a gold mine about two and a half miles from Candor, Montgomery County, North Carolina, and has just completed and put in operation a modern fine-grinding and cyaniding plant of 50 tons capacity, which has several unique and interesting points of divergence from general practice. (Plate III.) Not the least interesting feature of this property is its location in an agricultural, cotton, and peach-raising country. The points of technical difference are considered by the company to be strides forward in the practice of the treatment of gold ores, and the extraction being obtained, which varies from 94 to 97 per cent, is mentioned here to anticipate any hasty criticism of the details to be given.

The ore occurs in veins in a hard siliceous greenstone slate which has been much broken by joining. The country rock in this vicinity is cut by two diabase dikes, one of which has faulted the vein considerably, while the other apparently has not displaced it.

There are two veins on the property which in places are 6 feet wide, but which will average about 2 feet, and one of these has ore of commercial value developed by underground works for over 800 feet on the strike. The ore is a hard quartz, pearly grey in one vein and white streaked with red in the other, but in both cases hard and tough. The walls are in places well defined, but in others they are frozen to the vein, and either way much slate is broken down while stoping, so that hand sorting has to be resorted to both underground and on top. Of the rock as broken underground 10 per cent is sorted out by the muckers and sent up as waste. Later on this will be left in the old stopes, but conditions prevent it at present.

The veins have been opened at the present time (December, 1913) at the 100, 150, 225, and 300-foot levels, and the main shaft or No. 2 shaft has been sunk to nearly 90 feet below the 300-foot level. (Plate IV, A and B.) At the 400-foot level a station will be opened and crosscuts made to both veins.

THE UWARRA MILL.

The mine cars leave the cage at the landing station about 8 feet above the collar of the shaft and are trammed across a trestle 117 feet long to the crusher bin, and are there dumped onto a flat grizzly with

bars set 1½ inches apart. There are four ore pickers here who pick out 16 to 20 per cent more of the coarse slate which goes into the waste pocket of this crusher bin. This bin was formerly the stamp-mill bin in the former company's old Montgomery mill, and, because of its perfect condition, was removed and utilized in the new plant, though not exactly what would have been provided if a new one had been built; however, it serves the purpose very well.

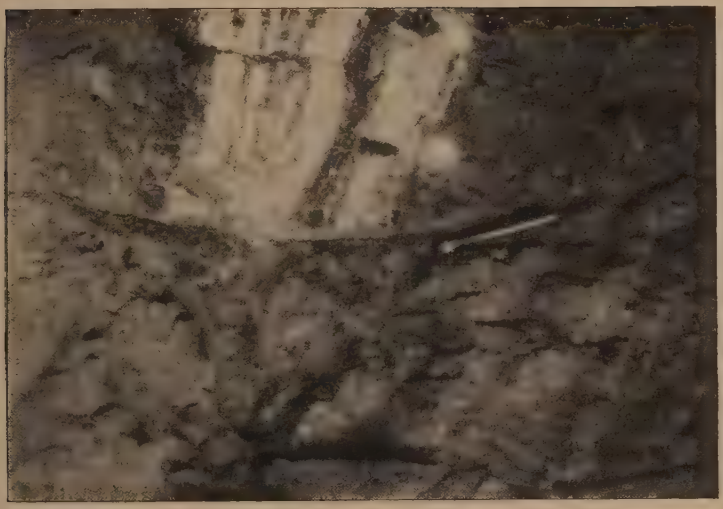
The ore is drawn from this bin through a standard 24 x 24-inch single rack and pinion steel plate gate and passes over an inclined grizzly with 1 inch opening to the crusher. The material through the grizzly drops directly to the loading hopper of the conveyor, to which also comes the product from the crusher, which is of the standard Blake type, size 15 x 9 inches set for 1¾-inch product. The jaw plates are of chrome steel.

This crusher is separately driven by a 7 x 10-inch Chandler and Taylor medium-speed throttling engine, horizontal type, and the engine and crusher are housed together in a crusher building separate from the mill but connected with it by the conveyor structure.

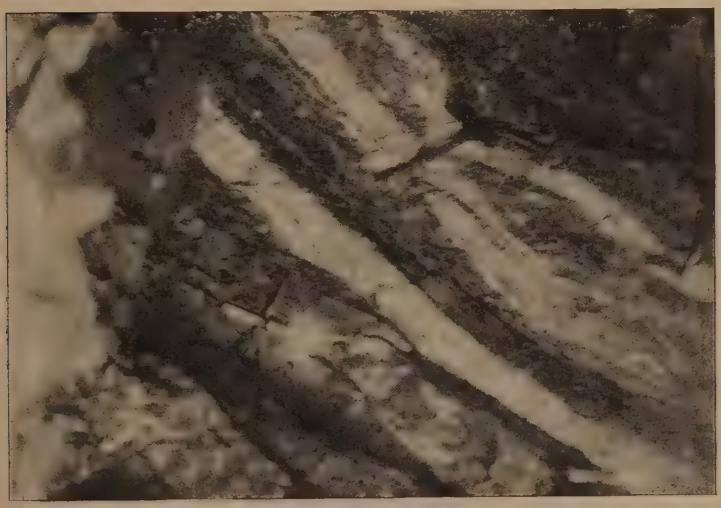
From the crusher and last grizzly, all ore is carried by a 14-inch wide troughed belt conveyor 88 feet, centers traveling on an incline of 20 degrees and at a speed of 250 feet per minute. This conveyor has a capacity much in excess of present needs, but was provided for future expected increase in tonnage from the mine. The belt is a 4-ply S. A. special conveyor belt with ⅛-inch rubber cover on the carrying side.

This conveyor is driven from the main mill shafting and discharges the ore into a cylindrical steel ore bin 12 feet in diameter by 20 feet high, which is the only ore-bin of this type in the East. This bin is without top or bottom, but is reinforced around both top and bottom with angle iron. The bin is supported on a concrete foundation which was made dodecagonal in shape instead of circular to save the cost of circular concrete forms, and with walls 12 inches thick and 6 feet 6 inches high. It was intended to reinforce this wall with expanded metal, but a long delay in its arrival made a substitute necessary, and heavy hog-wire fencing secured from a local hardware store was used in its stead with entire satisfaction. Inside of this dodecagonal foundation was filled with loose rock from the dump and a 2-inch layer of cement grout on top made the bottom of the bin. This bin is just outside of the main mill structure.

The ore from this bin is drawn through a standard 18 x 24-inch rack and pinion gate and fed by a 16 x 6-inch plunger feeder with adjustable eccentrics to the crushing rolls.



A. Faulted Vein on 300-foot level, Montgomery vein, Uwarra Mining Company, Candor, N. C.



B. Section of vein where picked up beyond fault.

We think this is the first modern all-sliming cyanide plant to use rolls exclusively for wet crushing between the rock breaker and tube mill.

A great deal of study, of course, was given to the selection of these crushing units. The writer has long been of the opinion that the stamp was out of place for this particular kind of stage crushing, for various reasons. To H. W. Dennison of the Allis-Chalmers Manufacturing Company, who collaborated with the writer in the design of this plant, belongs no little of the credit in the choice of these rolls. However, the adjoining mine, The Iola, owned by the Candor Mines Company, has been operating a mill* using 1,750-pound stamps, the heaviest in this country.

The use of heavy stamps in our mill would have been very objectionable also, because our only mill site was on the hanging wall of our vein not far from the shaft; this was but one more argument in favor of a rotary crusher. Various types were considered, but rolls were finally adopted, and while at this writing the mill has been in operation but ninety days, our judgment in the installation of rolls seems to have been fully justified.

Two sets of 24 x 10-inch Allis-Chalmers style B rolls were installed and operate under real wet crushing conditions, five tons of solution to one of ore going through the rolls. The roll shells are of low carbon steel. These rolls are not provided with automatic fleeting devices,† which were carefully considered, but were finally omitted.

Our first set of coarse rolls, getting the product from the Blake crusher set at 1¾ inches, naturally gets a very variably sized feed; the slate and slaty ore break into pieces, some of which may be 3 or 4 inches long and 2 or 3 inches wide, although only 1¾ inches thick. It is severe service to feed such material to rolls. However, some of our rock goes to the rolls thus, and we have very little or no trouble from them now that the feeders, both mechanical and mortal, have been properly adjusted.

Quoting from Mr. Holthoff's article, "Without abrasion there can be no corrugating. Abrasion is due to two causes: first, if the material fed is coarser than the rolls can nip without slipping; second,

*Iola Cyanide Mill, by Percy E. Barbour. Engineering and Mining Journal, Sept. 14, 1912.

†Mr. Holthoff, Engineering and Mining Journal, ... argues strongly against any fleeting device.

Mr. J. Parke Channing, in Bulletin 31 of the Mining and Metallurgical Society, states that the Miami has finally developed a fleeting device which fleets the roll once in 30 minutes, and by this slow movement entirely eliminates all the previous troubles had with various fleeting devices.

if the roll faces are running differential." Some of our feed, due to the cleavage of our rock, is probably too coarse from the above standpoint; and we expected corrugations, but at the end of ninety days we have only very slight corrugations on our coarse rolls, while on our fine rolls, where the feed is more uniform and none is too coarse, our roll shells are as smooth and straight as can be desired. In this connection, it must also be considered that our labor supply is drawn from local circles and we are operating with men who never saw a set of rolls before. Considering this, and the tough and very abrasive character of our quartz ore, we considered this a very satisfactory result, and we expect to take these corrugations out by hand adjusting and by regulation of the feed without the necessity of machining the shell. We cannot tell yet what the steel consumption will average per ton of ore, but present indications are that it will be satisfactorily low.

The product from both sets of rolls is elevated by an 8-inch wide bucket vertical belt elevator 35-foot centers, which discharge it into a set of two 30 inches diameter by 48 inches long standard trommels set in tandem. The first screen of 3-16 metal has ½ inch round punched holes and the second of No. 10 steel is perforated with 3-16 round holes.*

All oversize is returned by launder to the coarse rolls. All the screen product goes to the fine rolls and the fine material through the last screen goes to an Akins classifier, 45 inches diameter by 13 feet long. The choice of this classifier was influenced very largely by the fact that it had so few bearings to care for, oil, and maintain, compared to some others, and as for results accomplished, it has seemed to us that honors were pretty evenly divided. This classifier is giving perfectly satisfactory results as to classification, and is giving a tube mill feed so dry that it is necessary to add solutions.

The coarse sands from the classifier discharge directly into the feed box of the tube mill, which is of the gear-driven trunnion type, equipped with spiral feeder and reversed screw discharge. It is lined with Montana Tonapah iron bibbed lining. Danish flint pebbles are used.

The tube mill product is raised to the Akins classifier by an 8 x 44-inch standard Frenier pump, thus forming the usual closed circuit at this point in the flow sheet.

The overflow from the classifier goes to a Dorr thickener with steel tank 18 feet diameter by 8 feet deep. The overflow solution from this goes to the 12-foot diameter by an 8-foot pump tank on the lowest bench of the mill and is pumped back to the solution storage tank 10

*This screen will be changed for one of woven wire ½ inch mesh in order to get a coarser feed for and put more work on the tube mill.

Plant of Uwarra Mining Company, showing crusher building at left, conveyor building in center, and mill at right.

feet diameter by 22 feet high, located on the roll bench inside the mill building. For this service a 3½ x 4-inch Aldrich Triplex Pump belt driven is used.

The thickened pulp from the Dorr is handled to the agitators by a 2-inch Morris centrifugal pump. We are considering the replacement of this pump by a Frenier, because the abrasiveness of this ore is so great as to cause excessive wear on the rapidly revolving centrifugal, and the latter cannot be operated satisfactorily on this small tonnage to give continuous flow to the agitators, which is necessary for continuous agitation.

There are three Hendryx 8-foot diameter steel-shell agitators arranged for continuous agitation. This type of agitator was selected after an exhaustive series of tests in small agitators of the Hendryx type. (Plate VI.) A mechanical agitator was preferred to any other, because it was desirable to eliminate the use of compressed air: first, on account of certain local conditions; and, second, on account of the cost of compressed air, not only considered *per se*, but also considered as to its compression in a steam-driven straight-line machine versus agitation by mechanical power from the Corliss engine of the mill. These tests, which I hope to publish later, demonstrate the efficacy of this type of agitator for these ores, and the actual operation thus far bears out the result of the tests very closely. The agitation period is about eight hours to obtain the extraction as given, varying from 94 to 97 per cent. These agitators have steam coils inside the tank, and the pulp is kept heated to about 90 degrees, since our tests showed that this degree of heat was a decided advantage in accelerating extraction. The steam main from the boiler plant to the mill engine is a long one and is carried in an insulated buried box on a considerable incline. The heating pipe for the agitators is taken off from this steam line in the engine room in such a way as to trap all the water of condensation in the line, and we thus save much heat which would otherwise be lost. The power consumption of these three agitators as shown by indicator cards is 10.9, which is certainly satisfactorily low.

Owing to the fact that the filter works only during the day shift, a pulp storage tank between it and the agitators is necessary to hold the accumulation of the night shift mill run. This pulp storage tank is 17 feet in diameter by 10 feet high, with a conical bottom 9 feet 6 inches high, from the inverted apex of which the pulp is drawn to the filter. This pulp storage tank is provided with an overflow launder and a decanting device, which not only allows for sending a thick pulp to the filter, but also allows the removal immediately of a large amount of the pregnant solution without sending it through the filter.

The filter is a No. 1 type B Kelly Press, and it handles in one twelve-hour shift the 50 tons of dry slime ground per day. The operation of this filter and the results of same have been quite unusual. The solution is expelled from the cake until it contains only 8 per cent moisture, and the cake is then discharged as tailings without any washing whatever. The tailing as discharged, including both dissolved and unextracted values, often runs as low as 20 cents, and for the current month will average about 36 cents per ton of ore.

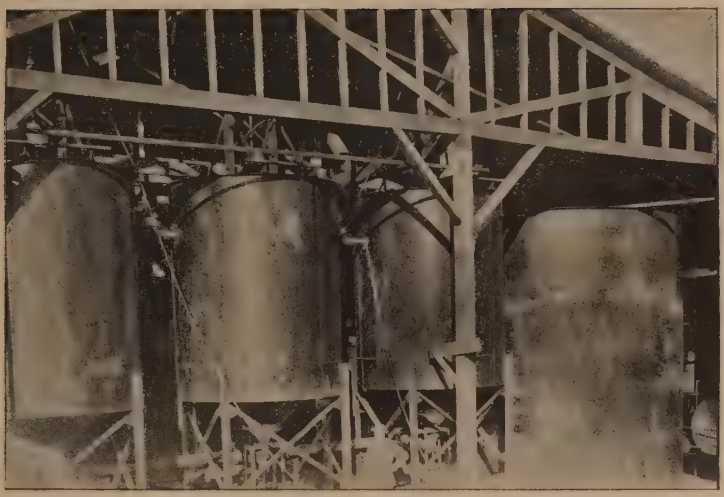
The pregnant solution from the filter goes to a 12-foot diameter by 8-foot gold sump tank, and is then pumped by a 1½-inch Morris centrifugal pump through an 18-inch square frame Shriver Filter Press for clarifying, from which it goes into a 12-foot diameter by 8-foot gold tank, from which it flows by gravity to three 6-compartment zinc-boxes, each compartment of which is 24 x 24 x 24 inches, filled with zinc shavings which are cut in the mill.

The barren solution flows to the 12 x 18-foot sump tank previously mentioned. The precipitate is handled in a 4-foot diameter by 3-foot deep clean-up tank, served by 2 x 3-inch Aldrich triplex pump; and the precipitate is then dried in a steel plate dry-pan 24 inches wide by 40 inches long, heated by steam, and is finally smelted to bullion in a No. 60 Steele Harvey Tilting Furnace fired by kerosene.

Every tank in the mill is of steel plate, and besides those enumerated, there is a water tank on the roll bench 10 feet diameter by 22 feet high, a duplicate of the solution tank. The only use for water in the mill is for flushing the cake from the hopper of the filter to the tailing dump down the "branch."

The circulating solution in the mill is kept at about 1.2 pounds KCN and the alkalinity about 2 pounds CaO per ton. No lead salts are used.

The mill is driven by its own engine of the Reliance Corliss type 12 inches by 36 inches, stroke running 150 r. p. m. with steam at 100 pounds at the throttle. A Wheeler 300 square feet surface condenser with combined air and circulating pump under a grating in the engine-room floor gives 25 to 27 inches vacuum, and the engine with maximum mill load indicated 93.7 h. p. The flywheel of this engine is 10 feet in diameter, has a square cross-section and weighs 7,500 pounds. In the engine-room and driven from the main shaft by a friction clutch cut-off pulley is a 10 kw. 120 v. direct current generator, running at 1,150 r. p. m., which furnishes lights for the entire job: mill, surface, houses, and underground stations. A model switchboard of black slate, 32 x 54 inches is furnished with a volameter and ammeter, detectors, rheostat, main switch, and eight current switches.



Agitators at the mill of the Uwarra Mining Company.

NOTES ON THE CARTER MINE, MONTGOMERY COUNTY.

By Claude Hafer.

"The Carter is one of the old mines of the State. In the '50s work was done here underground and on a placer known as Dry Hollow, which lays along the outcrop of the vein (approximately). Small tracts were leased in the hollow to working miners and a royalty paid on the gold won. The old dumps and pits are evidence of the work done, and it is yet possible to find little patches of virgin gravel that pan well. Lack of water prevented systematic work, and the whole gulch should pay to work by hydraulic methods, if a water supply was available in connection with underground operations. The deep mining was done by Mauney Brothers, who left here to go to Gold Hill, and the report was circulated that the vein had faulted or pinched out. The production during this lease is not known; local estimates have it from $100,000 to $200,000. From all obtainable sources of evidence the latter figure may be correct. The waste dumps are large and the fine from them assays $2 to $4 per ton. The writer unwatered the mine to a depth of 65 feet, and the works show that ore was removed both above and below this level for a considerable distance along the strike of the vein (150 feet). The country rock is a basic schist, that I have considered to be andesite, but have never had a slide made. The ore is similar to that of the Iola, and has probably a similar origin. In the north end of the old works is from 1 to 2 feet of solid ore, and in the south end are 2 feet consisting of quartz stringers interlaminated with the country schist. A drift into this mass of stringers passed out of the quartz and encountered pyritic schist that was gold-bearing; on continuing the drift, the quartz would undoubtedly come in again. The ore and country rock lay nearly flat, dipping 10 to 20 degrees from the horizontal, except in one heading in the north end, where the ore intersects a mass of barren quartz and pinches to a mere stringer which at times is obliterated. The entire formation is crumpled and folded, and the country rock included in the quartz mass is altered to a soft product as free from grit as soapstone, and resembling it in many ways. After folding into a sharp anticline, both schist and included ore dip steeply at an angle of 50 to 55 degrees, and in addition to the small stringer are two larger ones in the hanging wall, making a total of more than a foot of ore. The steeper dip is normal; a railroad cut a fourth mile to the northeast, cross-cutting the country for miles, shows this as the general angle of dip. A shaft sunk by writer 50 feet deep, near the railroad, follows the ore steeply all of the way. In sinking, several faults were encountered, in one of which the plane of the fault

was nearly horizontal, but no such flattening or crumpling as in the old works. The flattening is evidently a fold antedating all other rock deformation (except perhaps the fissuring along which the barren quartz was deposited, unless this is a product of segregation) and also ore deposition. To the north and east everything dips at a high angle, while south and east everything is flat. The old miners did a good deal of work below the 65-foot level, but this was the limit of unwatering. In some places they followed the vein as it turns and dips more steeply, and in other places they followed the same dip as the works above the level. Other than the opening, there is no evidence that they had ore. With a small flat vein, it was necessary to remove waste material in order to have working space, some of this was hoisted, but much was packed in the mine openings in lieu of timber, and after more than fifty years the works are still accessible in most parts. There is a little tendency to blockiness, locally, but the ground is generally solid and stands well; it is hard to drill and easy to blast. At 65 feet both ore and inclosing rock are heavy with sulphide, though there is much free gold. Water level is at 45 feet, and the collar of the shaft is more than 75 feet above the nearest water-course. All developed ore has been taken out, but high-grade ore should be easily developed on the 65-foot level. The ore in the north end was low grade, assaying $6 or $7 per ton, is soft and can be cheaply mined; in the south end assays were from $16 to $80 per ton. The shaft sunk near the railroad followed several stringers of quartz that are probably the northeast extension of the vein in the old mine. There are other veins on the property; none of them show gold in the pan sufficient to indicate ore of value, if the mine is worked; however, it will be well to investigate them by means of trenches to cut possible outcropping ore sheets. The tract includes 200 acres, well wooded and well watered. The Norfolk Southern Railroad passes through the property. Near-by is the hall of the Reynolds property, on both of which mining exploration has been done, and on which some good grade ore occurs.

"(My work at the Carter was brought to an end because there was no opportunity to dispose of the ore in such small quantities as my limited funds allowed me to mine it, but now that the Iola mill will purchase ore, it is a likely prospect to work on, although the price is high.)"

THE HOWIE MINE.

The Howie Mine, which was formerly operated by the Colossus Gold Mining and Milling Company, has recently been purchased by the Howie Mining Company and extensive preparations are being made to develop and operate this property on a large scale. It is located about

A. Open cut at "Glory Hole," Howie Mine, Montgomery County.

B. Mill and Power House of Howie Mining Company.

3 miles east of the town of Waxhaw, Union County, and 22 miles south of Charlotte. The company owns about 250 acres of ground.

The country rock of this section is a dark-colored argillaceous slate which is usually very highly silicified, and having a strike of N. 55° E. Traversing this area are many so-called veins or ore seams or streams, varying from 18 inches to 16 feet in width. The ore is very similar to that occurring in many other sections of the silicified slates, and it is often very difficult to determine where the vein material ends, and it is usually necessary to constantly test the vein material and limit the mining at that point where the value is so low that it does not pay to take out the ore. It is, however, very rarely that this can be determined by the external appearance of the ore, and assaying is necessary. Pyrite occurs in the vein material and also in the wall rocks. These quartz seams and veins have a strike of N. 55° to 65° E. and a very steep dip from almost perpendicular to slightly to the northwest. Cutting the slates and the quartz seams are several diabase dikes, which have a northwest strike. The rich ore seems to be in the vicinity of these dikes. The ore body might be said to be that portion of the slates adjoining the quartz seams where the gold occurs as fine films on the cleavages and join planes of the slates.

In the early history of the mine, it was developed by a series of shafts, the deepest of which was the Cureton, 300 feet deep. Most of the mining carried on by the present company has been done by the "Main Shaft" (Cureton). The total depth of this shaft is now 355 feet.

*"Two levels have been opened, one at 150 feet and one at 265 feet. At the 150-foot level, drifts have been run southwest and northeast on the vein without any pay ore having been exposed. Cross-cuts extend southeast and northwest from the shaft, also in waste. The total amount of drifting and cross-cutting is about 200 feet.

"At the second level, drifts have also been run southwest and northeast, and cross-cuts same as on the first level. In the southwest drift an ore body was encountered about 100 feet from the shaft, and a stope has been started on the ore. Ore is being broken here from 6 to 8 feet wide, averaging by grab samples from $10 to $300 per ton. The higher values have been recently found in the southeast wall of the stope, the rich portion of the vein being from 1 foot to 18 inches wide, and averaging from $70 to $400 per ton in gold. Very little silver is found. This rich ore is at present being sacked for shipment, the balance going to the mill.

*From letter of Robert Clark, superintendent of the Howie Mine, to the State Geologist, December 26, 1913.

"The mill ore will average from $10 to $30 per ton. The bulk of the gold occurs on the cleavage planes in a very fine state of division, the remainder being disseminated through the quartz in coarser particles. Gold is readily seen with the naked eye in the rich ore.

"The bottom of the shaft, 90 feet below the second level, shows assay values of $2.40 per ton, and the intention is to sink further, with a view of cutting the same ore shoot now being worked on the second level.

"This ore shoot is south and east of the old workings in the Bull Face shaft, operated some years ago by the Colossus Mining Company, and sunk on an incline to a point 90 feet below our second level.

"There is a break through from the southwest end of our drift on the second level into these old workings, but up to the present time water has prevented any examination of the old work, and their extent has not been ascertained by the present company. According to report, a considerable amount of ore has been mined from these old workings. The Bull Face shaft is vertical for 150 feet from the surface, the remainder of the distance being on an incline following the dip of the ore shoot. There is said to be good ore left in the bottom.

"Northwest from the Bull Face are two other shafts, the old and new Neddy shafts. These are in bad condition, and are not being used. The new Neddy produced a considerable amount of good ore from the Neddy vein to a depth of 300 feet. This vein parallels the Bull Face vein on the northwest. There is a cross-cut connecting the Bull Face and the new Neddy shafts at 150 feet.

"At a point 1,500 feet northeast from the main shaft the company is developing a vein exposed in some old workings. This shaft is 60 feet deep and has been equipped with a small headframe and hoist. A 1½-inch air line from the main shaft supplies compressed air to operate the hoist and machine drills. Sufficient development work has not yet been done in this shaft to determine the extent of the ore shoot, but good ore is being broken in an underhand stope from 2 to 3 feet wide.

"Ore is trammed from the main shaft to storage bins, from which it is taken to the mill by an inclined tramway. This incline is to be extended on a 45-degree dip to cross-cut the vein systems in this the western end of the property."

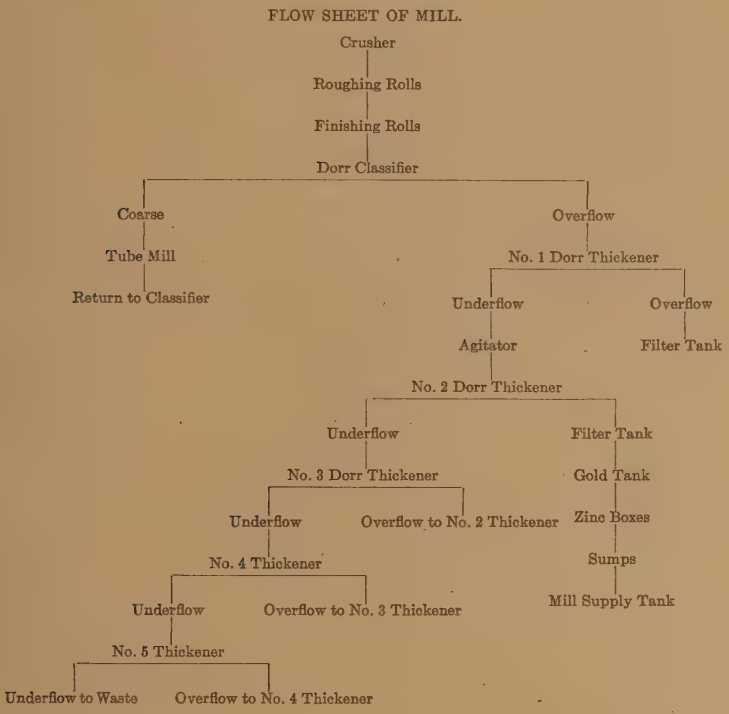
THE HOWIE MILL.

The mill has been remodeled by the present company from a dry crushing plant to a cyanide agitation plant, crushing in cyanide solution. It consists of Gates crushers, roughing rolls, finishing rolls, tube

A. Tube Mill and Finishing Rolls of Howie Mining Company.

B. Another view of Cyanide Tanks.

mill, classifier, necessary elevators, tanks, etc. An outline of the arrangement of this mill is given in the following chart:



THE COGGINS (APPALACHIAN) GOLD MINE.

The Coggins Mine is located in the northeastern part of Montgomery County, North Carolina, 1½ miles north of Eldorado, the nearest postoffice, and 12 miles northeast of Troy, the county-seat. The nearest railroad point is Whitney, on a branch of the Southern Railway, running from Salisbury to Norwood, a distance of about 7 miles nearly west.

The mine property consists of three tracts: One known as the "Mine Tract," containing 62 acres, on which is located the mine and all buildings connected with its development—the company's office, the assay office, manager's house, crushing plant, stamp mill, and concentrating plant. A second tract, containing 20 acres, is on the Uwharie River,

about one-quarter of a mile to the south, and contains considerable timber and cordwood. The third tract contains 1 acre and is on the Uwharie River, just above the second tract. Here is located a pumping plant, which is connected with the water tanks at the mine by a 3-inch pipe.

A description of this mine will indicate or give the salient features of several other mines in this general district.

GEOLOGY.

The country rocks of this area are composed of argillaceous slates or schists, which have probably been derived from land detritus or waste, and varying amounts of tuffaceous material. Cutting these rocks at sharp angles to their schistosity are diabase dikes, which vary from a few to 6 feet in width. The strike of the schistosity of the slates is approximately N. 42° E., and they are dipping from 75 to 80° northwest. The slates are both soft and silicified and carry quartz lenses or stringers from very small narrow ones to some that are 10 or more feet in width. These slates have very evidently been faulted, and the resulting fault line has followed pretty much the schistosity of the slates; but in some instances it has cut across this at a very sharp angle. The result of this faulting has been the formation of quartz veins referred to, and also to a general silicification of the slates. The width of the slates which have been subjected to this mineralization and silicification varies up to as much as 50 to 60 feet. Another result of the mineralization has been the introduction of considerable gold-bearing pyrite into the bands of schists or slate. Some of this pyrite occurs in minute cubes up to one-eighth of an inch in diameter. There is a decided difference in the origin of the free gold in the quartz seams or slates and that which occurs in the gold-bearing pyrite. I believe it will be found that considerable of the gold in the pyrite occurs as free gold, and not in chemical combination with the iron sulphide or as a gold sulphide. Specimens were found in which free gold occurred in perfectly fresh pyrite. The gold runs out into very minute cracks in the pyrite, so that it is impossible to crush the ore fine enough to liberate all this gold without causing slimes. For this reason all the free gold cannot be saved by amalgamation.

The veins have a lenticular structure, as observed in horizontal and vertical planes, varying very widely in width, both along the strike and dip, and are separated by bands of schists or slates from other similar quartz veins. The ore body of this band of mineralized slate can readily be divided into two types: one consisting of numerous very nar-

row stringers of quartz, lying along the planes of schistosity of the rock, and which are separated from each other by narrow bands of slate which contain more or less pyrite, but which are not very silicified; and the other type containing larger masses of quartz occurring in veins or seams, and the slates inclosing them are silicified to a much greater extent.

There is a great variation in the values carried by these ore deposits, and there seem to be well-defined ore shoots which also have a lenticular structure and which are richer than the balance of the vein. In some instances the foot and hanging walls are well defined, but in many cases the walls of the vein could only be determined by assaying the ore to determine to what extent the vein could be profitably worked. To one who is unfamiliar with this formation it is often very difficult to distinguish between the rich and lean portions of the vein. It is absolutely necessary in working this type of deposit to constantly sample the ore to determine its value, and the position of the vein for ore seams.

Diabase dikes have been observed cutting the schists and ore deposits, but they have been intruded subsequent to the formation of the ore, and it must have faulted or displaced the ore deposits but very little.

Three diabase dikes have been observed, two of which were exposed in the underground workings and the third at the extreme end of the "mine tract" in an open pit.

MINERALOGICAL CHARACTER OF THE ORE.

The ore consists principally of free gold, with some pyrite and a gangue of white quartz or silicified slate, or both. The pyrite seems to be more or less disseminated through the schists and carries some gold, which it is believed is largely in the free state. The seams of slate that occur in the vein are also impregnated with small particles and crystals of pyrite, although their gold content is often very low. These barren portions vary in width from a few inches to several feet.

A small amount of calcite has been observed in the quartz seams, and a very small amount of arsenopyrite.

The veins are altered usually to a depth of 50 to 70 feet, but in some instances they are partly altered to a still greater depth.

VEINS.—There are two so-called veins that have been developed: one known as the "East Vein" and the other known as the "West Vein"; but as far as can be determined, these two are parts of one general ore formation and do not represent two distinct depositions of ore. The

two bands of slate impregnated with the quartz veins and seams were supposed to be separated by a band of barren slate, but it was found upon sampling this that it carried a certain amount of gold.

Development Work.—The property has been developed principally by one shaft, with its drifts and cross-cuts. A certain amount of prospecting has been done at other points along the strike of the slates. At the southwest end of the property in a line S. 42° W. from the shaft, a pit (A) about 8 feet deep was sunk along the edge of a diabase dike. At several points between this pit and the shaft, several cross-cuts were made, exposing the slates, but it did not show any mineral of value. To the northeast of the shaft, several pits have been made, the principal one being about 400 feet from the shaft, where a pit (B) was sunk 12 or 15 feet, that exposed the slates. This pit was approximately N. 42° E. from the shaft.

The main shaft was sunk vertically for a distance of about 8 feet, and then was turned, following approximately the dip of the slates; and is continued on this incline to the lowest level, approximately 260 feet. Four levels have been developed from the shaft: one known as the "50-foot Level," which is approximately 57 feet from the collar of the shaft. Another level known as the "100-foot Level," a third known as the "200-foot Level," and a fourth known as "250-foot Level."

50-foot Level.—On the 50-foot level development work has been extended for a distance of 142 feet to the southwest of the shaft and 172 feet to the northeast of the shaft. At a point 60 feet southwest of the shaft, a diabase dike was encountered; and 130 feet northwest of the shaft another diabase dike was encountered. (Fig. 1, p. 53.) Most of the work on the 50-foot level has been stoping of ore that existed between these two dikes; and the ore has been taken out very largely from this level to the 100-foot level, also to a considerable extent from this level toward the surface. (Fig. 2.) Blocks and pillars of ore have been left, some of which carry good values, but have not been reckoned as a part of the ore in sight. There seem to be two veins of ore, separated by a block of slate that carries considerably less value than the veins; but, as tested in certain places, carry pay values. At the extreme northeast of the drift of this 50-foot level the slates were tested, which show no free gold; and this indicates that beyond the diabase dike on the northeast there is but little ore, unless it should be found that the ore-bearing portion of this slate has been faulted. To the southwest of the southwest dike ore was encountered and stoped for a distance of about 30 to 40 feet. The extreme southwest end of the drift was tested, which showed a certain amount of free gold; indication that the ore

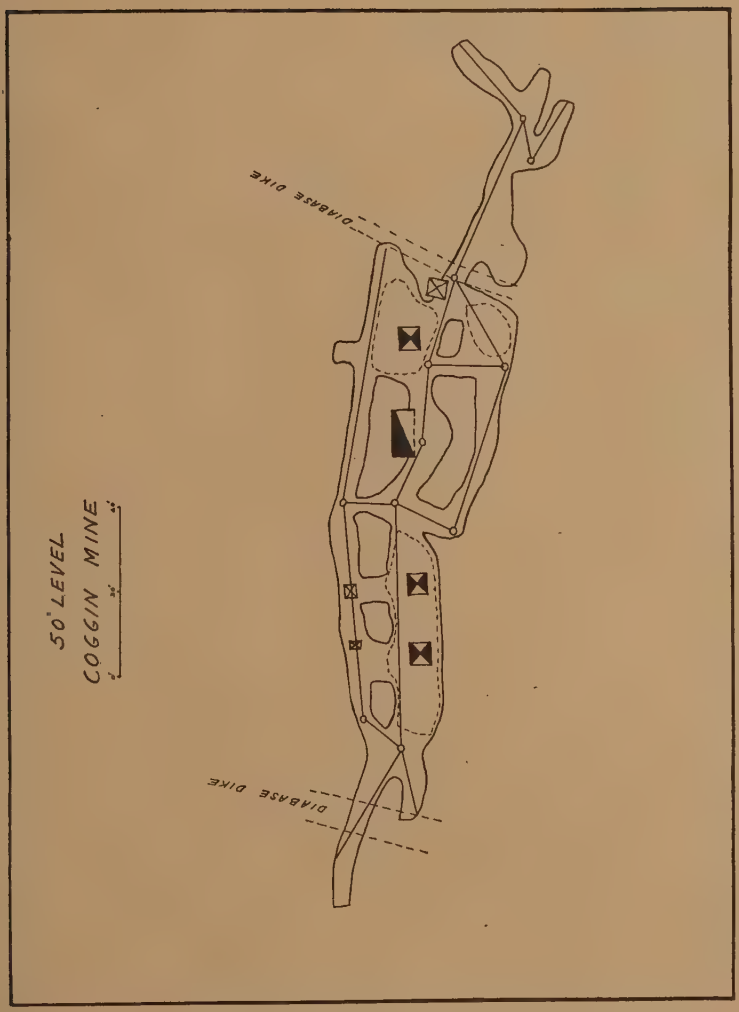


Fig. 1.

body was continuous in this direction. The 50-foot level is connected with the surface by an upraise of 50 feet to the southwest of the shaft, and with another of 60 feet to the northeast. It is also connected with the 100-foot level by a winze from the stope to the southwest and a stope to the northeast of the shaft. (See plan of level, Fig. 2, p. 55.)

100-foot Level.—On the 100-foot level development work has been extended for a distance of 60 feet to the southwest of the shaft and 102 feet to the northeast. Besides the stoping that was done from this level toward the 50-foot level, considerable underhand stoping has been done to the northeast of the shaft; and a winze has been sunk from this stope to the 200-foot level. The ore as exposed on this level was very carefully sampled, so that a comprehensive idea can be obtained of the occurrence of the ore bodies. There seems to be two ore shoots to the northeast of the shaft, separated from each other by a band of slate, which, however, is gold-bearing, as indicated by the two samples assayed, which showed $2.11 and $2.51 value in gold. The southwest ore body has been developed by a drift and cross-cut, and the ore as exposed was carefully sampled. This gave a value of approximately $9 per ton, for a width of approximately 20 feet. The work to the southwest of the shaft is apparently in the barren or partially barren band of slates, separating the two ore shoots, which accounts for the low values obtained from the assaying of the slates in the vicinity of the shaft. The southwest stope of this 100-foot level, which comes within 12 feet of this level, encountered on the southwest the diabase dike, which accounts for the stoping being stopped in that direction. The cross-cut was extended to the southwest from the winze connecting this stope with the 100-foot level for a distance of 45 feet; and then another drift was extended for about 30 feet to the southwest, cutting through the diabase dike. A sample was taken of the supposed ore just beyond the dike, but this showed but very little value. (See plan of level, Fig. 3, p. 56.)

200-foot Level.—On the 200-foot level development work has been extended for a distance of 90 feet to the southwest and 120 feet to the northeast, and the ores have been stoped at two points: one at the extreme southwestern portion of the level and the other about 20 feet from the extreme northeastern portion of the level. Both overhead and underhand stoping have been done. Neither of these stopes connect with the 100-foot level; but a connection with the 100-foot level is had by the winze sunk from the northeast stope of the 100-foot level to a cross-cut on the 200-foot level, which is to the southeast of the stope. The development work on this 200-foot level indicates that the so-called

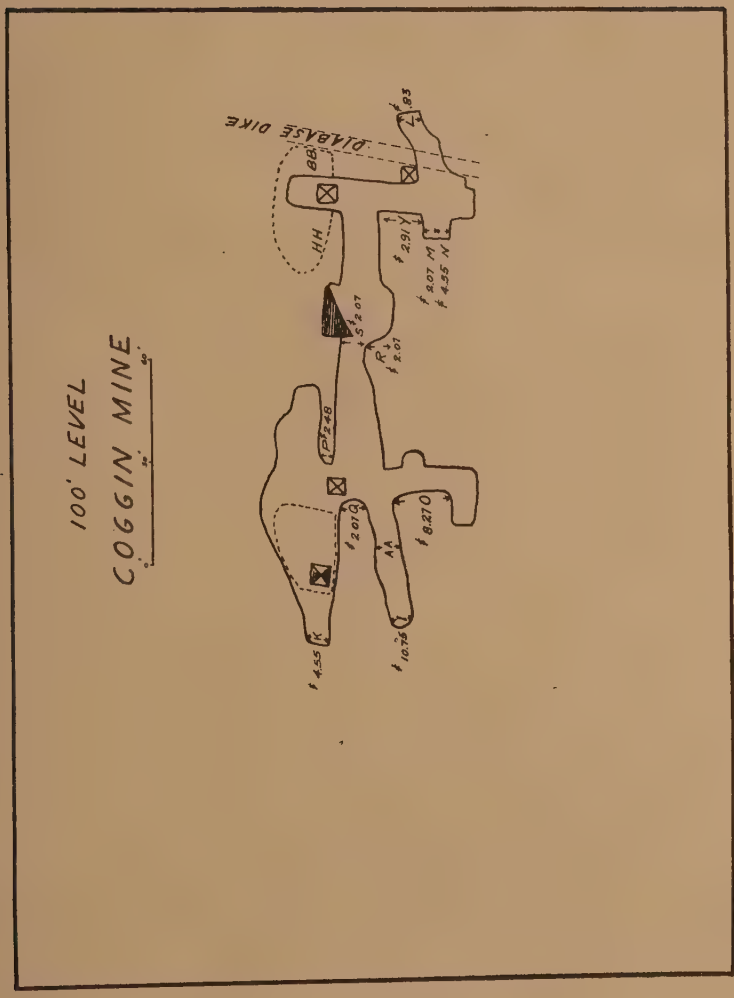

100' LEVEL
COGGIN MINE
DIABASE DIKE
DIABASE DIKE
HH
BB
AA
CC
1P248
1201Q
8270
1078
455 N
455 N
207 N
435 N
291 Y
201 R
207 S

FIG. 2.

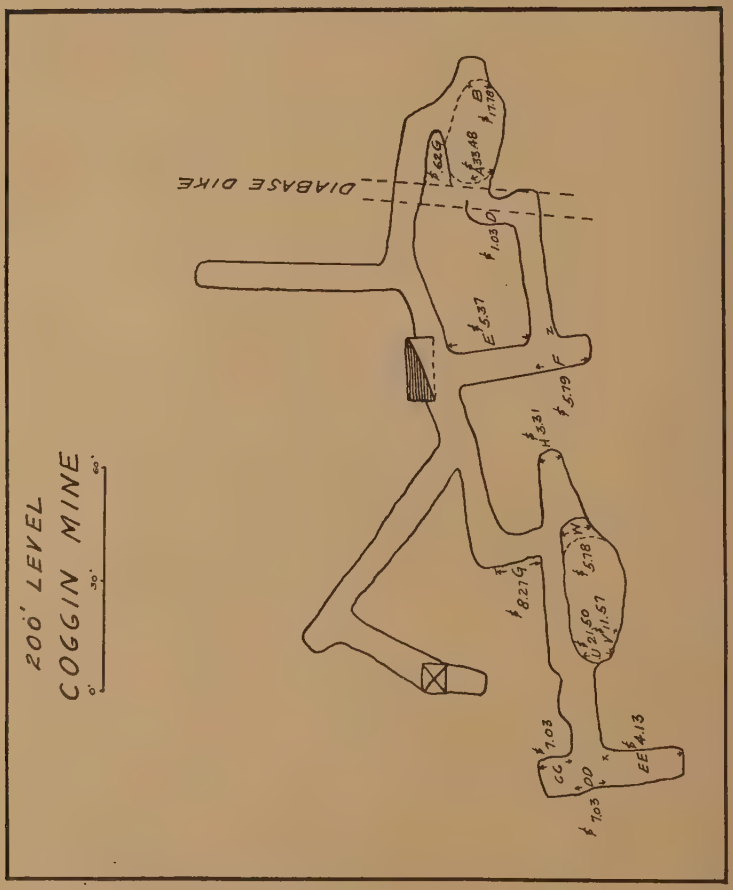

200' LEVEL
COGGIN MINE
0'
20'
40'
DIABASE DIKE
B
$1,719
$3348
$629
$1.03
$5.37
E
F
$5.19
H
$3.31
$8.27
G
$5.78
M
$21.50
$11.57
$7.03
CC
DD
$7.03
EE
$4.13

FIG. 3.

"two-ore bodies" of the 50- and 100-foot levels have come together on this 200-foot level. As assayed, an ore body is developed on this level 42 feet wide at the northeast portion of the level, which carries values of approximately $6 per ton for the whole width. The northeast stope is on the richer ore shoot that occurs in the vein, and has been stoped for a width of about 15 feet. The assays made of this ore shoot showed values varying from $5.82 to $21.54 per ton. The southwest stope of this level is on the richer portion of the ore body, just southwest of the diabase dike, and showed values of $17.82 and $32.52 per ton. This stope is about 12 feet wide. Between these two stopes, a distance of approximately 90 feet, there is a block of ore that has been developed by means of cross-cuts, that gave values varying from $3.38 to $8.30. There is apparently a seam of slate in this ore body that carries very low values. The whole body of ore, approximately 40 feet in width, will be found to carry approximately $5.50 to $6 per ton. The ore shoot to the southwest undoubtedly extends further to the southwest than has been developed.

It was impossible to get down into certain of the stopes in order to take samples at the bottom of the stopes between the 100- and 200-foot levels, and also the upper portions of the stopes from the 200-foot level. Two sides, however, of the block of ore between these two levels have been sampled and assayed, which will give an approximate value of the ore body; and this value has been used in reckoning the ore body.

250-foot Level.—At the 250-foot level a drift has been run a distance of 47 feet, N. 50° W. At a distance of 37 feet drifts were started northeast and southwest on a rich vein or seam of ore. As assayed, this seam carried from $170 to $232 in gold. Portions of it were rich, one 2-foot sample assaying $677 per ton. The material taken out of this cross-cut and the drifts show ore delivered to the mill on my last visit to the mine, January, 1914. The drifts from this cross-cut had only been extended a distance of 6 or 8 feet. A winze was started from the northeast stope of the 200-foot level to connect with the northeast drift on the 250-foot level. On account, however, of the difficulty in keeping good air in the winze, work was stopped on this, and an upraise will be made from the 200-foot level to connect with this winze.

The percentage of free gold in the ore at the 250-foot level is approximately the same as at the 200- and 100-foot levels. It is very interesting to note, and indicates that this type of ore is carrying free gold to considerably greater depth than had been expected.

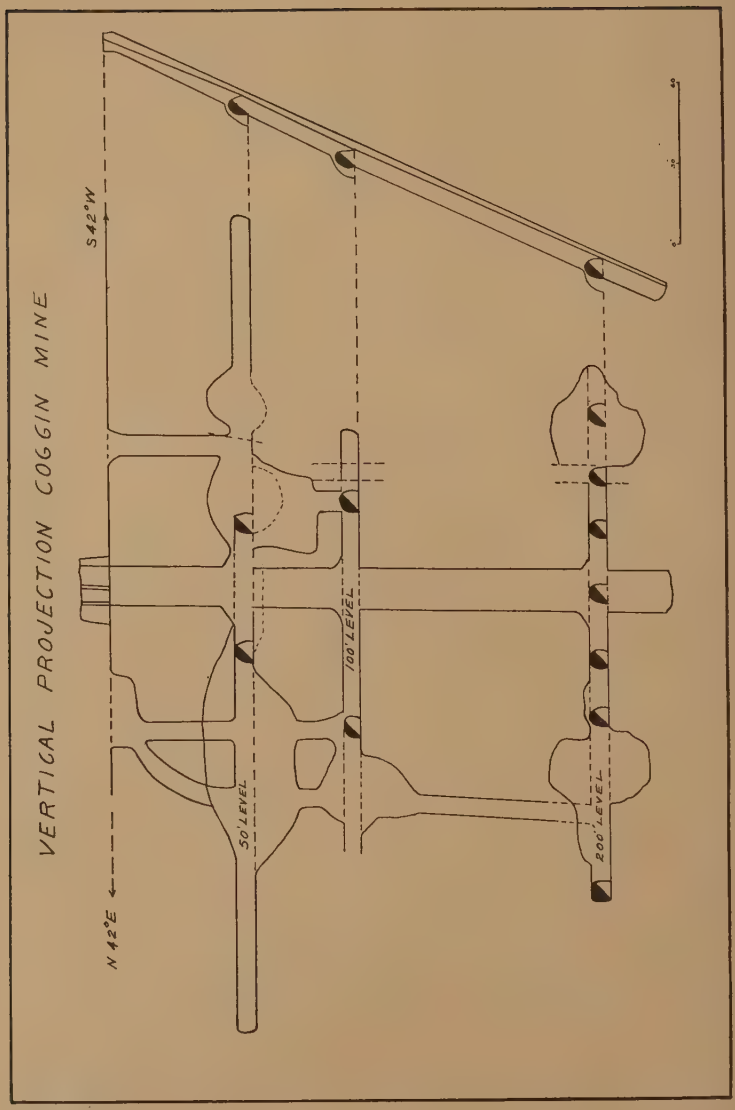

VERTICAL PROJECTION COGGIN MINE
S 42° W
N 42° E
50' LEVEL
100' LEVEL
200' LEVEL

FIG. 4.

Northeast Pit.—This pit, which is about 400 feet N. 42° E. from the main shaft, is 13 x 13 feet, and has been sunk to a depth of approximately 15 feet. This pit exposed the slates which, for a width of 6 feet, contained numerous seams and veins of quartz. The strike of the slates was approximately the same as that at the shaft, and their dipping, if anything, a little more vertical. All the slates were badly decomposed to the depth of the pit. A sample was taken from across the width of this open pit, and upon panning showed considerable free gold.

Southwest Pit.—This pit, which is at the extreme southwest portion of the 62-acre tract, has been sunk to a depth of about 6 to 8 feet alongside of a diabase dike. The strike of the schists that were exposed is approximately N. 43° E., and the strike of the dike approximately N. 20 to 30° E. A sample was taken of the slates as exposed in the pit just to the northeast of the dike; but, upon panning, this did not show any free gold, although some pyrite.

Assays of Gold Ore, Coggins Mine.

Sample.	Level.	Description.	Width.	Value in Gold.
A	200 ft.	Southwest stope	6 ft. 6 in.	$ 33.48
B	200 ft.	Southwest stope, opposite end from A	5 ft. 10 in.	17.78
C	200 ft.	Just east stope, supposed wall rock	2 ft. 3 in.	.62
D	200 ft.	Just northeast of dike. All slate	10 ft.	1.03
E	200 ft.	West cross-cut from shaft. Mostly slate with seams of quartz	17 ft.	5.37
F	200 ft.	Last 12 ft. cross-cut. Northeast side	12 ft.	5.79
G	200 ft.	Cross-cut to northeast stope. Section east of stope	11 ft. 6 in.	8.27
H	200 ft.	Extreme southwest end of northeast stope	4 ft. 7 in.	3.31
I	100 ft.	Extreme end. Almost western to the northeast drifts	4 ft. 6 in.	10.75
K	100 ft.	Extreme end of the easterly northeast drift	5 ft. 10 in.	4.55
L	100 ft.	Extreme southwest end just beyond diabase dike	4 ft.	.83
M	100 ft.	Southwest cross-cut. Slate 3 ft. 3 in.	3 ft. 3 in.	2.07
N	100 ft.	Next 5 ft. 8 in. beyond M	5 ft. 8 in.	4.55
O	100 ft.	Northeast cross-cut. Northeast side	9 ft.	8.27
P	100 ft.	Southwest end of northeast stope	6 ft. 2 in.	2.48
Q	100 ft.	Junction of two northeast drifts	8 ft. 5 in.	2.07
R	100 ft.	Just east of main shaft. Northeast side of chamber	9 ft. 6 in.	2.07
S	100 ft.	Nine ft. to the east of R, extending partly beyond shaft	9 ft.	2.07
T	100 ft.	2 ft. seam of quartz of S	2 ft.	1.65
U	200 ft.	5 ft. above bottom northeast stope, northeast end	5 ft. 10 in.	21.50
V	200 ft.	Just southwest U, 3 ft. to 4 ft. above bottom of stope	3 ft. 5 in.	11.57
W	200 ft.	Southwest end of stope. 3 ft. above bottom	8 ft. 11 in.	5.78
Y	100 ft.	Southwest cross-cut. Northeast side of first 8 ft. of slate	8 ft.	2.91
AA	200 ft.	Westwardly northeast drift. 31 ft. 6 in. from face. Sample across roof	12 ft. 10 in.	10.33
CC	200 ft.	Extreme northeast cross-cut. East section	14 ft. 8 in.	7.03
DD	200 ft.	Same as CC. Next 10 ft. 10 in. to west	10 ft. 10 in.	7.03
EE*	200 ft.	Next 16 ft. 10 in. to DD to west	16 ft. 10 in.	4.13

*Assays A to EE were made by Mr. Frank Drane, Charlotte, N. C.

Assays of Gold Ore, Coggins Mine.
(Continued.)

Sample.	Level.	Description.	Width.	Value of Gold.
A-2*	250 ft.	North side of cross-cut, 33 ft. from shaft	8 ft.	$ 232.68
B-2	250 ft.	South side of cross-cut, beginning 33 ft. from shaft	8 ft.	171.51
C-2	250 ft.	South side of cross-cut, beginning 33 ft. from shaft	2 ft.	12.64
D-2	250 ft.	Next 2 ft. to C-2	2 ft.	218.99
E-2	250 ft.	Next 2 ft. to D-2	2 ft.	677.59
F-2	250 ft.	Next 3 ft. to E-2	3 ft.	70.38
G-2	250 ft.	North side cross-cut, beginning 33 ft. from shaft	3 ft.	258.90
H-2	250 ft.	Next 2 ft. to G-2	2 ft.	73.79
I-2	250 ft.	Next 2 ft. to H-2	2 ft.	10.02
J-2	250 ft.	Next 2 ft. to I-2	2 ft.	3.08
K-2**	250 ft.	South side of cross-cut, last 3 ft. 2 in. of cross-cut	3 ft. 2 in.	1.26
L-2**	250 ft.	Next 1 ft. 6 in. to K-2	1 ft. 6 in.	1.44

*Assays A-2 to L-2 were made by Mr. Henry McCoy, Ophir, N. C.
**It was considered when these two samples were taken that they were beyond the ore-bearing seam, and the assays indicate this.

The ore bodies exposed in the Coggins Mine were carefully sampled, and the location from which the samples were taken indicated by letters on the maps. (Figs. 2 and 3, pp. 55 and 56.)

In addition to the above samples, several other samples were taken, which were panned to determine whether or not the ore tested was carrying free gold, and the relative amounts. The panning samples were quartered and the amount panned usually weighed from 1 to 3 pounds. These samples were taken as follows:

Sample.	Level.	Description.	Width.	Value in Gold.
Z	200 ft.	Quartz seam in drift from cross-cut in front of shaft.	2 ft.	Showed several nuggets of gold ¼ dwt. to 1 dwt. and many colors.
BB	100 ft.	Southwest end of southwest stope. Material next to diabase dike.	2 ft.	Showed 3 good colors and many minute ones.
GG	100 ft.	Overhead southwest stope. Sample taken next to diabase dike.	9 ft.	Showed one good color, several minute ones. Several pyrite.
HH	100 ft.	Northeast portion of southwest stope to quartz seams.	2 ft.	Showed two fair colors and considerable fine gold.
II	50 ft.	Extreme southwest end		Showed several small colors, some pyrite.
MM	50 ft.	Extreme northeast end beyond diabase dike.	4 ft. 10 in.	Showed no free gold. Some pyrite.
OO	50 ft.	Just southwest of diabase dike of southwest drift. Siliceous slate.	6 ft. 7 in.	Showed fair colors and many minute ones. Some pyrite.
PP	Surface	Pitt B	13 ft.	Many colors.
QQ	Surface	Pitt A	3 ft.	No gold.
XX	200 ft.	Northeast stope sample taken from material left on supposed hanging wall.	10 ft.	Nine fair colors. Many minute ones. Some pyrite.

A 10-stamp mill with four sets of amalgamation plates and two Wilfley concentrating tables has been erected. The ore as it is brought from the mine is raised to a hopper, from which it is fed to a Gates crusher, which feeds it onto an endless belt. This conveys the ore to the hopper, which feeds to the stamp mill. The capacity of the mill is approximately 30 tons per day.

There seems to be but very little tendency for the ore to slime, and a very good separation is obtained. One run of ore from the winze that was being sunk from the 200-foot to the 250-foot level, which gave $19.75 on assaying, gave tailings assaying 90 cents. The ore from the 200-foot level, as it was delivered to the mill, assayed $53.20. Tailings from this ore assayed $4.35 on the first run. On the second run, where the ore assayed $54.02, the value of the tailings had been cut down to $2.88. The concentrates from the first run gave values of $133.03, and on the second run, $81.57. This, of course, is accounted for by the fact that the concentrates were not as clean as in the first run. The concentrates were carefully tested by panning, but showed no free gold. This was also true of the tailings, which indicates that there is a very complete amalgamation of free gold on the plates. The fineness of the Coggins gold, as determined in the Laboratory, was 904.

COPPER.

There has been but very little activity in the copper industry in the State since 1907, although each year there has been a small production of this metal. In the Blue Wing District there has been a certain amount of development work at several of the properties since 1907, yet the production of copper ore has been very small, which is also true of the Gold Hill District, Rowan County. The Cullowhee District of Jackson County made a production in 1912. The Hazel Creek Mining District of Swain County and the Ore Knob Mining District of Ashe and Alleghany counties have both been idle during the past five years. There are many reasons why these various districts have been idle; but, perhaps, the chief one is the low price of copper.

In the Cullowhee District, the Cullowhee Copper Mining and Reduction Company operated the Cullowhee Copper Mine during a portion of 1912. The ore bodies occur along the contact of an amphibolite and the Carolina gneiss, this latter being one of the principal rocks of this section. It is comparatively low-grade ore, consisting principally of chalcopyrite, mixed with pyrite in a siliceous gangue. A small amount of chalcocite and covellite has also been found. This mine has been

developed by means of a shaft 177 feet deep with drifts running at various levels out on the vein, following the ore body. There was recently installed a 30-ton water-jacketed smelter which made a low-grade matte.

During 1912, in the Blue Wing District of Person and Granville counties, prospecting work was carried on at the Hollaway Mine on what is supposed to be a new vein of copper ore, and it is probable that both this property and the Blue Wing will again be in operation in the next year or two. The Copper King Mine, owned by Mr. J. H. Morong of Virgilina, Va., is also expected to be in operation in another year.

In the Gold Hill District it is understood that the Union Copper Company has recently been reorganized, and that this property may soon be again in operation and the producer of copper.

In Guilford County, the Twin-Edwards Copper Company and the Gardner Hill Mine will probably be developed, when the smelter at Charlotte is completed. This smelter, which is being erected by the North Carolina Partridge Smelter Company, should be the means of causing many of the copper properties in this State to be reopened and become producers of copper.

There are several properties in Davidson, Randolph, Rowan, Stanly, and Guilford counties that should be able to produce ore, which they could ship to the smelter at Charlotte at a profit.

The Conrad Hill Mine is located 6 miles east of Lexington, Davidson County, and is one of the more noted mines of this county. In the early history of gold and copper mining in North Carolina this mine produced a considerable amount of both copper and gold. There is considerable slag lying around where the old furnace was located; and in 1912 Mr. J. P. Laban, who controls this property, had a car-load of this slag shipped to Perth Amboy, N. J., which gave 4,466 pounds of copper, 19.08 ounces of gold, and 39.9 ounces of silver. This will indicate somewhat the richness of the ore that must have been treated in the furnace, if the above values were left in the slag.

PRODUCTION.

The production of copper in 1912 was 63,766 pounds. There was no production reported for 1911. This output of copper was obtained from 500 tons of ore, which had a yield of 151.8 pounds of copper and of $2.25 of gold and silver per ton.

In the table below there is given the production of copper ore, and the amount and value of copper obtained from this for the years 1900 to 1912, inclusive:

Production of Copper from 1900 to 1912, Inclusive.

Year.	Crude Ore Mined.	Copper Produced.	Value.
	Tons.	*Pounds.*	
1900	6,948		$ 41,600
1901	10,398	512,666	76,900
1902	16,741	1,417,020	212,553
1903	4,106	458,133	67,037
1904	4,250	305,000	36,600
1905	10,000	488,888	88,000
1906	11,729	703,775	135,829
1907	11,011	597,878	116,416
1908	180	19,393	2,560
1909	3,575	224,512	29,186
1910	2,221	140,514	17,845
1911			
1912	500	63,766	10,521

LEAD AND ZINC.

It has been many years since North Carolina entered the field as a producer of lead and zinc. There is in Davidson County a unique mineral district which contains ore bodies, known as the "Silver Hill type," that are described in detail in Bulletin No. 22 of the North Carolina Geological and Economic Survey, and which contains ore of a complex mixture of sulphides, chiefly galena and sphalerite, with some chalcopyrite and pyrite, the whole carrying silver and a little gold. In the upper workings these sulphides were largely altered and decomposed, forming bodies of carbonate ores, carrying high gold and silver values. The Silver Hill Mine is noted for the large amount of free silver that is obtained. Where the ores were decomposed and oxidized there was little trouble in saving the gold and silver; but as the mining operations were continued in depth, unaltered sulphides began to be encountered, and then difficulty was experienced in saving the values. It is now possible, however, to take these complex ores and make a satisfactory separation of their various metal content.

This mine was operated in 1912 under the supervision of Mr. T. A. M. Stephenson of Silver Hill, N. C., and the production of lead and zinc reported was from this property.

The Silver Valley Mine, situated about 5 miles north of the Silver Hill Mine, contains ore of a similar character.

PRODUCTION.

In 1912 there were 1,215 short tons of the lead and zinc ores treated, which yielded approximately $648 in gold, 283,320 pounds of zinc, and 92,000 pounds of lead. The value of the lead and zinc was $25,694.

IRON.

North Carolina contains not only very large deposits of iron ore, but some deposits that contain an ore which makes an exceptional grade of iron. One such deposit at Cranberry, Avery County, has been worked almost continuously since 1876. In 1882 a narrow-gauge railway was built connecting the mine with Johnson City, Tenn., and it was then that regular systematic mining was undertaken. This ore was first worked in a small way in Catalan forges as early as 1820, and the quality of the iron made soon became known, and attracted considerable attention throughout the East. This is a magnetic iron ore, which is distributed in irregular masses through the gangue, composed of hornblende, pyroxene, epidote, quartz, feldspar, calcite, garnet, serpentine, etc., in varying proportions, and is in the form of immense lenses. There is undoubtedly a large quantity of this type of ore in the Cranberry District, and the deposits are adapted to pig iron at a low cost.

Similar deposits of magnetic iron occur in Ashe County and were operated on a small scale as early as 1802, the ore being reduced in Catalan forges. This iron also became well known, and it was shipped as far as Charlotte, N. C., and Charleston, S. C., where it was prized above all other irons obtainable. During the War Between the States these ores were used in manufacturing iron which was made into gun barrels. The people of Ashe County continued to make iron from this ore as late as 1887, using for this purpose the old Catalan forge. The cheaper and lower grades of iron manufactured from other points and shipped into this county made it impossible for the iron manufactured from the Catalan forges to compete with it. The reason why these ores have not been developed has been a lack of transportation facilities. Such conditions, however, are now changing, as The Virginia-Carolina Railroad, owned and controlled principally by the Norfolk and Western Railway, is building a line from Abingdon, Va., into the iron ore region of Ashe County. With the completion of this railroad, there is no doubt but that these iron ores will be developed on a large scale, and it is not unlikely but that Ashe County will become a large producer of as fine iron as is put on the market.

Both the Avery and Ashe County deposits were described in Bulletin No. 1 of the North Carolina Geological Survey, which was published in 1893.

Recently (June, 1914) the author made an examination of certain of the magnetic iron ores of Ashe County, the results of which are given below:

MAGNETIC IRON ORES OF ASHE COUNTY.

The magnetic iron ore deposits examined are located in the northeastern portion of Ashe County, principally along the north fork of New River and its tributaries that flow into it from the north. The deposits can readily be divided into three belts: one known as the "River Belt," including the N. B. Ballou, Calloway, Neaves, and W. H. Brown properties; the "Poison Branch Belt," including the Uriah Ballou (Waughbank), the Graybeal, the Ballou-Piney Creek, Francis, McClure, Poison Branch, the G. Douglas Blevins or Falls, and Red Hill properties; and the third, "The Helton Creek Belt," including the Kirby and Sturgill properties.

While formerly these deposits were twenty or more miles from the railroad, the one now being built across Ashe County will bring the Ballou-Piney Creek, the Joseph Graybeal and Waughbank properties within a very short distance of the railroad.

These ores are all magnetic iron ores, occurring in crystalline rocks which consist principally of hornblende gneisses and schists and micaceous schists. The deposits of ore are undoubtedly lenticular or lens-shaped, and are pinching and widening in all dimensions. These lenses may continue for long distances along the strike and on the dip; then, again, there may be a series of smaller lenses separated from each other by country rock or connected with each other by a thin seam of ore. Sometimes they may be so small as to be of no commercial value; while at other times they attain enormous size, both in length and depth. Usually these ore deposits are conformable to the enclosing country rock. Each ore locality has to be investigated as a separate unit, inasmuch as there is great variation in them, and it does not follow that because one ore deposit is well developed that another one, even in the same belt, will be equally as good. These lenses have a general northeast-southwest trend.

The deposits examined include the Calloway and W. H. Brown properties of the "River Belt"; the Waughbank, the Graybeal, the Ballou-Piney Creek, Francis, McClure, Poison Branch, Falls, and Red Hill properties of the "Poison Branch Belt"; and the Kirby and Sturgill properties of the "Helton Creek Belt."

RIVER BELT.

The principal property examined in this belt is known as the Calloway property, the mineral interest of which is owned by Mr. Uriah Ballou. It adjoins a portion of the old N. B. Ballou property, the mineral interest of which is now owned by the Virginia Iron, Coal and Coke

Company. The iron ore outcrops at the top of the hill, and has been developed by means of cuts and tunnels, so that the ore is exposed at various points from the top of the hill to the creek, 150 feet or more below. The principal development work on the Calloway property is a tunnel that was started about 140 feet below the top of the hill. This tunnel was extended in a N. 35° E. direction for a distance of 103 feet, when it encountered the iron ore. A crosscut was made in order to determine the width of the ore, and it exposed a width along the crosscut of 27 feet 8 inches, which would give a width across the vein of about 20 feet. The strike of the vein is approximately N. 45° E. The crosscut, after penetrating the ore, was turned N. 70° E., and then 60° west, following the hanging wall until it again encountered the ore, which it followed for a distance of 17 feet 8 inches without penetrating the ore body. This gave a horizontal distance of about 30 feet along the vein. This same ore body outcrops at the surface at several places between this level and the top of the hill. By means of float and a few crosscuts this ore belt can be traced in a southwesterly direction for a distance of about a mile across what is known as the Davis property and the Neaves property, when it crosses the north fork of New River. The deposit narrowed considerably, but where it crosses the river it is reported to have a width of 12 feet. On the Calloway property it is estimated that there is a distance of 450 feet of the vein from the tunnel to where it crosses onto the property owned by the Virginia Iron, Coal and Coke Company. Average samples of the ore as exposed in the tunnel were taken across the vein, where cut by the crosscuts. Results are given in analyses I and II of Table of Analyses.

The ore is very much mixed with gangue, but it is a schist ore body. The magnetite can readily be separated from the gangue and largely concentrated by hand cobbing.

On the side of the hill controlled by the Virginia Iron, Coal and Coke Company sufficient crosscuts and tunnels have been made to show that the vein is continuous across the property.

POISON BRANCH BELT.

The first property examined in this belt is known as the Poison Branch mine, the mineral interest of which is owned by Mr. Uriah Ballou and Mrs. Davis. The ore was encountered near the summit of a hill dividing the waters of Old Field and Silas creeks. Openings were made into the ore on both sides of this divide. Considerable work has been done on this property, part of which was to obtain ore for the old Catalan forge. This ore was obtained from two open cuts on the northeast side of the road, one on each side of the divide. Fifty feet below the

summit a tunnel 181 feet in length was run into the hill, from which crosscuts were made: one at the extreme end of the tunnel; another 45 feet towards its mouth; and a third 114 feet from the end. The strike of the vein is approximately N. 40° E., and the dip about 45° S. E. Both the first two cuts cut across the vein for a distance of a little over 9 feet, which would give a vein of an actual width of 4½ to 5 feet. A third crosscut was run for a distance of over 33 feet, but this was as far as it could be entered at the present time, as it had been filled up with waste material from some other part of the mine. No ore could be seen in this crosscut. Average samples of this ore were taken, and the results are given under III in the Table of Analyses beyond.

The foot wall of this deposit is a mica schist, while the hanging wall is a hornblende gneiss. This ore belt has been traced in a southwest direction from the Poison Branch property for a distance of about 3½ miles crossing the McClure, Blevins or Falls, Uriah and Graybeal properties. It is questionable whether the deposit itself is continuous, and it is more than apt to be cut by lenses of magnetite, which may or may not be connected with each other. With the exception of the McClure property, the ore was observed in place on all of the properties. On this property, however, the cuts have become filled up so that no ore at all was exposed. Previous investigations, however, made by Mr. H. B. C. Nitze of the State Geological Survey showed conclusively the continuation of the magnetic iron ore belt across this property, and it is in practically a direct line from the Poison Branch occurrence to that outcropping to the Falls property adjoining.

The Falls or Blevins Property.—This property, which was formerly known as G. Douglas Blevins property, is now owned and controlled by B. G. Falls and Charles Blevins. This property is about 3 to 4 miles southwest of the McClure. The ore is exposed in a vein which outcrops in a ledge above Mr. Falls' house. The ore is a hard magnetite occurring in an epidote gneiss. There is also considerable of the epidote occurring as a gangue with the magnetite. The vein as exposed on the outcrop of the ridge is about 8 feet wide. The strike is approximately N. 50° E., and the dip about 45° to the southeast. About 60 feet below the summit of the ridge a tunnel was run 60 feet into the hill, which cut but did not penetrate the vein. To the northeast of the vein on the same property there is another occurrence of magnetite that outcrops on the W. Jones property.

Ballou-Piney Creek Property.—About half a mile south, a little west of the Falls property, there is an occurrence of manganiferous magnetite on the Uriah Ballou land just above the waters of Piney Creek,

about 1½ miles from its mouth. An open cut has been made here just below the road, which exposed 18 feet of ore, which would make the vein 12 feet across. The ore is very coarse grained, very free from gangue, but containing near its center a 15-inch seam or vein of soft brownish-black manganese-iron oxide. This ore was sampled and the analysis showed 64.56 per cent of metallic iron. For complete analysis see VI of table below. The soft brown ore was also analyzed, showing 42.80 per cent of metallic iron. See analysis VII in Table of Analyses.

About 85 feet above the cut described above the ore was exposed in a cut 4 to 5 feet deep. A granular ore, similar to the above, was found. The full width of the vein was not exposed. A sample of this ore gave 65.50 per cent of metallic iron. See analysis V or table. About 40 feet still higher on the hill another cut 3 feet deep also exposed the same kind of ore. The lateral distance represented by the exposures made in the three cuts mentioned above is approximately 350 feet. The lead has been traced by means of float for a considerable distance beyond that exposed in the upper cut. The above all indicates that there is a lens of very large size on this property.

Ballou's Horse Creek, or Waughbank Property.—This property is about 1½ miles southwest of the Ballou-Piney Creek property on the north bank of Horse Creek. About 100 yards from the creek a tunnel was run by the Pennsylvania Steel Company. The tunnel has a direction of N. 40° E., and at a distance of 100 feet a crosscut was made extending 46 feet S. 40° W.

This crosscut showed ore for its whole distance, making the width of the ore deposit over 30 feet. This ore is composed of coarse granular magnetite in a matrix composed of micaceous material and manganese oxide. A rough estimate indicates that about 70 per cent of the ore body would represent the iron ore. This material was sampled and the results of the analysis are given in VIII-A in the table beyond. This mineral can readily be cobbed, which will raise the iron content. A sample was also analyzed of the magnetic iron portions of the vein, which gave 67.25 per cent of iron. The results of this analysis are given in VIII of the Table of Analyses.

Seventy-five to one hundred feet above the tunnel the vein was exposed in an open cut; but, on account of the cut having caved in, nothing definite could be determined in regard to the width of the vein. On account of the width of this deposit it should be thoroughly developed.

Graybeal Property.—About one-half a mile northeast of the Waughbank property begins what is known as the Graybeal properties. The first property encountered is the Calvin Graybeal. Only a very little de-

velopment work has been done on this property, but float ore has been encountered, which would indicate the continuation of the ore formation across the property.

A short distance north from the top of the hill on the Calvin Graybeal property on lands owned by the Patton family and Calvin Graybeal, a cut exposed magnetic iron ore mixed somewhat with the country schist. This may be part of an ore deposit that is known in that section as the "North vein," which extends approximately parallel with the regular ore formation, being approximately 200 to 300 yards north of the larger vein.

It is about one-fourth mile from the top of the Calvin Graybeal hill to the Joseph Graybeal property in a general northeast direction. The vein has a strike across this property of an approximately northeast direction, and it is dipping toward the southeast. The ore deposit has been prospected and developed by means of open cuts, pits, and tunnels for a lateral distance of at least 800 feet and a vertical distance of over 100 feet. A drill hole was made by the Pulaski Iron Company at a point about 700′ to the southeast of the first open cut, and 75′ below. It is reported to have encountered the ore at a depth of about 200′. The dip of the vein would bring the ore body to this point. The width of the ore body as encountered varied from 4 to 15 feet.

The first cut examined was partially filled, so that the extent of the vein could not be determined. Good ore is exposed in the cut, thus showing the continuance of the ore body. This work was done by the Virginia Iron, Coal and Coke Company in 1907. Three hundred feet to the northeast another cut exposed the vein, which had a width of at least 15 feet of nearly solid ore, there being a little of the ore mixed with finely divided gangue rock. An analysis of this ore showed 63.50 per cent metallic iron. At the mouth of the cut, about 30 feet from the vein, another small seam of ore 12 to 15 inches thick was exposed. Most of this work was done about 1890 or 1892. Part of it was done in the early days of iron mining in the county, when the ore was obtained for the Catalan forges.

Still further to the northeast a long open cut or trench was made by Mr. Sturgill in 1903 across the ore deposit. At the time of my visit, however, it was nearly all filled up, and the ore was only exposed at the east end of the cut.

Float ore has been found between all the cuts referred to.

On the opposite side of the hill several cuts and tunnels have been run which penetrated the ore body, showing that the ore was continuous through this hill. Most of the work was done by the Virginia Iron, Coal

and Coke Company in 1907. The first cut is about 300 yards northeast of the Sturgill cut referred to above. The first work done at this cut was in the early days to obtain ore for Catalan forges. Near the mouth of the cut an iron manganese seam of ore was encountered 6 feet wide, the distance between the two veins being about 30 feet. This ore has been analyzed, and the results are given in XIV of the Table of Analyses. Iron=63.15 per cent.

Thirty feet below this cut a tunnel was run into the hill. This was partially caved, so that it could not be examined except near its mouth, where a manganese iron vein was observed. Judging from the material found on the dump, the ore encountered in the tunnel was very similar to that in the cut referred to above.

Two hundred and fifty feet northeast of this tunnel another open cut was made by Dr. Tom Jones in 1905, and work was continued by the Virginia Iron, Coal and Coke Company in 1907. This cut exposed a seam of magnetite about 4 feet wide, which it penetrated. In the upper end of the cut there was exposed a mixture of pyrite and hornblende. Thirty feet below and 30 feet northeast of this cut a tunnel was run by the Virginia Iron, Coal and Coke Company, and later continued by Dr. Jones. This penetrated the ore body. There was exposed near the mouth of the tunnel a manganese iron seam of ore.

From this point it is 300 yards northeast to the Joseph Graybeal line. Beyond this property is the Dr. Thomas Jones land which has been prospected for the whole distance along the course of the ore by means of shallow cuts and pits. Only at one or two places was the ore exposed in place.

Henninger Property.—Adjoining the Dr. Jones property on the northeast and east are the Francis and Henninger properties. About 500 feet from the Dr. Jones line a small open cut was made, which showed granular magnetic ore. Six hundred feet northeast of the first opening another open cut shows similar ore. These two cuts were made by Mr. E. Sturgill about 1903 or 1904. These openings are near the barn of Mr. Eugene Ballou, who now owns the property.

Francis Property.—This property, which is between the Henninger and the Ballou-Piney Creek properties, has been developed to some extent by means of open cuts and tunnels, but at the time of my visit no ore could be observed in place. This ore was observed in place by Mr. H. B. C. Nitze of the North Carolina Geological Survey when he made an investigation of the Ashe County iron ores.

Red Hill Property.—The Red Hill property is near the northeast extension of the Poison Branch ore belt. The Red Hill rises about 170 feet

above the level of the creek, and a trench over 200 feet in length has been made from one side of the hill to the other near its summit. While it did not expose a vein of solid magnetite ore, it did show a decomposed schistose rock, which carried almost throughout its entire extent masses and particles of magnetite scattered through it. There have been many openings made at various points on the hill which encountered magnetic iron ore. In some of the cuts more or less pyrite was observed, which will have a tendency to increase the sulphur content of the ore.

HELTON CREEK BELT.

Kirby Mine.—This mine is located on the upper waters of Helton Creek, about one-half mile north of Sturgill postoffice and one-fourth of a mile from Helton Creek. The ore body on this property was exposed by a series of cuts made by the Pennsylvania Steel Company in 1902. One cut about 55 feet above a small branch showed ore exposed for a distance of 17 feet. Another cut 25 feet still higher on the hill showed a similar exposure of ore. This ore was in a gangue of epidote and hornblende. On the opposite side of the branch a long open cut was made by Mr. Sturgill in 1892. The mineral interest is owned by Mr. J. L. White and Sheriff Sturgill. Analysis of the ore is given in XVI of the Table of Analyses. The iron content of 43.10 per cent can easily be increased by hand cobbing.

There is given in the table below analyses of the ores from the various properties mentioned above.

Table of Analyses.

Locality.	No.	Iron.	Manganese.	Silica.	Phosphorus.	Sulphur.	Titanium.	Analyst.
Calloway Property	I	31.26		17.37	.028	.10		Drane.*
Calloway Property	II	38.36						Drane.
Poison Branch Property	III	45.25		20.65	.052	1.58	trace	C. & M.†
Falls Property	IV	43.25						C. & M.
Ballou-Piney Creek Property, upper cut	V	65.50	2.81					C. & M.
Ballou-Piney Creek Property, near creek	VI	64.56	2.59	2.06	.014	trace	none	Drane.
Ballou-Piney Creek Property, Mn-Fe vein	VII	42.80	17.48					C. & M.
Waughbank Property	VIII	67.25	1.68					C. & M.
Waughbank Property, Magnetite	VIII-A	46.25	4.34		.026	.027	trace	C. & M.
Graybeal Property, first cut	XI	67.40		1.15	.005	.060	none	C. & M.
Graybeal Property, second cut	XII	63.50						C. & M.
Graybeal Property, large cut at top hill	XIV	63.15	3.58					C. & M.
Kirby Mine	XVI	43.10		21.76	.057	.036	trace	C. & M.

*Frank Drane, Chemist, Charlotte, N. C.
†Crowell & Murray, Chemists, Cleveland, Ohio.

As will be seen from the above analyses, there is considerable variation in the metallic contents of the ore, but the iron content is good, and as they are all comparatively low in sulphur, phosphorus, and titanium, they will, therefore, make iron ores of high value.

Analyses I and II of ore from the Calloway property are low in iron, but they represent samples taken across the full width of the ore deposit, including gangue and waste. By hand cobbing this ore can readily be raised to a 55 to 60 per cent iron ore. The magnetite portion of the vein gives as high as 65 per cent metallic iron.

The ores represented by analyses III, IV, and VIII-A can also be easily concentrated by hand cobbing.

All the ores tested are a splendid grade of magnetite, and should make a pig iron of exceptional quality.

WATAUGA COUNTY IRON ORE.

About 7 miles southeast of Boone, Watauga County, and near Cook's Gap, there is an iron ore deposit known as the "Bull Ruffin." The ore is a magnetite, which is very pure, of rather schistose structure, with small octahedral crystals disseminated through it. This ore body is now attracting some attention on account of the construction of the Watauga and Yadkin River Railroad, which will pass near this property, and it is now being developed to determine something accurate about the quantity of ore that the deposit will contain.

A company known as "The Carolina Ore Company" of Winston-Salem was recently organized for the purpose of converting the refuse from a sulphuric acid plant into ore briquettes or nodules, which can be shipped to the iron furnace in Virginia. This company has made contracts with a number of other plants for their iron oxide refuse, with which they will make iron ore. In the manufacture of sulphuric acid from pyrite, if the ore is thoroughly roasted so that the sulphur is nearly completely driven off, the refuse, which is an iron oxide, will make a good ore of iron. In many instances the distance of transportation of this material to a blast furnace has prevented its being used as a source of iron.

PRODUCTION.

In 1911 and 1912 the production of iron ore for North Carolina was obtained entirely from the Cranberry Mine of Avery County. In 1911 this amounted to 84,782 long tons, valued at $148,369; in 1912, to 68,322 long tons, valued at $186,264.

There is given in the table below the production and value of iron ore for North Carolina from 1900 to 1912, inclusive:

Production of Iron Ore in North Carolina, 1900-1912, Inclusive.

Year.	Amount Long Tons.	Value.
1900	21,000	$ 42,000
1901	2,578	4,997
1902	34,336	52,771
1903	82,851	78,540
1904	64,347	79,846
1905	56,282	70,352
1906	56,057	75,638
1907	75,638	113,488
1908	48,522	76,877
1909	61,150	107,013
1910	65,278	114,237
1911	84,782	148,369
1912	68,322	186,264

The name of the company is the Cranberry Furnace Company, Johnson City, Tenn.

TIN.

There continues to be considerable interest manifested in the tin ores of North Carolina. The occurrence of this tin ore has been described in detail in Bulletin No. 19 of the North Carolina Geological Survey. The most development work has been done on the property of the Piedmont Tin Company, near Lincolnton, Lincoln County; and although but little tin ore has been put on the market, this company has carried on development work almost continuously since it took hold of the property. They have now developed up their main deposit by means of one shaft 140 feet deep, another 74 feet deep, and a third 75 feet deep. Drifts have been run at the 100-foot level of the 140-foot shaft for a short distance, which were along the vein.

The company is still working on this main shaft, and will continue to work until it has been sunk to the 300-foot level, running out drifts from 200- and 300-foot levels. The company is attempting to block out a sufficient amount of ore of known value that will warrant them in installing the right kind of mill for treating the ore on a large scale.

PRODUCTION.

There was no production of ore from this mine in 1911, but in 1912 during the development work about 600 tons of ore were taken out, which were concentrated. The value of the concentrates obtained is included in the value of "Miscellaneous Minerals," given in the table on general mineral production on page 16.

MANGANESE ORES.

In Gaston County there occurs a belt of manganiferous slates that outcrop along the western base of Crowder's and Kings mountains. These slates are of a very dark, bluish-black color, impregnated with manganese dioxide, through which are disseminated particles of chrysotile pyrolusite. These slates extend into York County, South Carolina, where they have been prospected to some depth, indicating that the black slates grow gradually richer in manganese with depth. Various analyses have been made of these slates from different depths, showing a manganese content varying from 51 to 57 per cent metallic manganese. The phosphorus content of these ores is very low, which makes it a good quality of manganese ore.

In 1910 the North Carolina Bessemer Company was organized and took over a certain area containing these manganiferous slates. One car-load of manganese ore was shipped to Pittsburg, but on account of the one who made the shipment not being familiar with the ore, it was not very carefully selected, and too low-grade ore was shipped.

NICKEL.

At all of the peridotite formations which occur so abundantly in Western North Carolina, nickel silicate has been observed. This occurs in some of them simply as a stain on a rock, while in others it has been found in the seam nearly one-half an inch thick. On account of the intense green color of the nickel silicate, these seams and spots are very conspicuous, and often give to the rocks the appearance of containing a large quantity of nickel silicate. This nickel was originally a constituent of the peridotite rock, but during its alteration, nickel silicate has been segregated in the seams formed during the decomposition of the rock.

Localities where the nickel silicate has been observed in greatest quantity are just south of Democrat and near Alexander, Buncombe County; near Webster and near Balsam, Jackson County; and near Elf, Cherokee County.

The only attempt that has been made to mine any of these nickel ores has been at Webster, Jackson County. This property has been developed by means of about sixty open cuts and pits, and one tunnel 154 feet long. Diamond drilling has also been carried on, the deepest hole being sunk to a depth of 162 feet. It is reported that an average sample of the ore that it is expected will be treated in the electric furnace, erected for this purpose, will run 1.75 per cent nickel. It is not

known whether this assay represents the run of the rock, or those portions of the rock which contain the seams and particles of nickel silicate.

A special process has been devised for treating this ore, and a patented electric furnace erected for this purpose. One charge has been run through the furnace, and it is reported that the run was a success, the metal, nickel, being satisfactorily separated from the ore.

The name of the company at Webster, N. C., is the Consolidated Nickel Company.

PYRITE.

The Oliver Pyrite Mine, which is located about 6 miles from Dallas, is now being operated by the Southern Sulphur Company of Scranton, Pa. The pyrite occurs in seams and lenses which have been continuous along the strike and in depth, but with varied thicknesses. The present company is developing the property by means of a stope that they have driven to a depth of 260 feet, which, according to a report from Mr. F. C. Fuller, treasurer of the company, shows 51 inches of ore in the face, where it has been developed by means of bunches. The quality of the ore is extremely good, and contains 42 to 48 per cent sulphur for the lump ore.

ABRASIVE MATERIALS.

The production of abrasive materials in North Carolina has not amounted to any large sum since 1901, when the corundum industry came to a standstill. Since that time, with the exception of the years 1903 and 1905, there has been no corundum reported as having been produced in the State. There is, however, a demand again arising for North Carolina corundum, and it is not improbable but that within the next two or three years corundum will again be mined in this State. The two other abrasive materials that have been mined in this State for the past fifteen years are garnet and millstones. The garnet has been produced in Madison, Clay, and Jackson counties; the millstones in Rowan County, near Salisbury.

PRODUCTION.

All the garnet produced in North Carolina during 1911 and 1912 was from the property of the Blue Ridge Garnet Company, N. N. Rogers, manager, located near Shooting Creek, Clay County. The garnet rock is crushed in a stamp mill and concentrated on a Bartlett table. All the concentrates were shipped to Europe.

The production of millstones was reported by two producers in 1911 and by three in 1912, all from Rowan County.

There was a small amount of feldspar mined and shipped, that it was claimed was used for abrasive purposes.

The total value of the production of abrasives in 1911 was $9,773; and in 1912, $10,914.

Production of Abrasive Materials, 1901-1912, Inclusive.

Year.	Corundum.		Garnet.		Millstones.		Total Value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Tons.		*Tons.*		*Pairs.*		
1901	325	$ 48,840	775	$ 43,000		$	$ 91,840
1902			260	10,040	50	1,425	11,465
1903			*403	12,250	63	902	13,152
1904			*202	6,586	208	6,500	13,086
1905	†1,150	9,000			196	2,652	11,652
1906					205	4,100	4,100
1907							‡15,469
1908						4,052	4,052
1909						9,188	9,188
1910						7,981	7,981
1911							§9,773
1912							a10,914

*Including production of corundum. †Including production of garnet.
‡Including corundum, garnet, and millstones. §Including garnet and millstones.
aIncluding garnet, millstones, and small quantity of feldspar, said to have been used for abrasive purposes.

MICA.

PRODUCTION.

The total production of mica in North Carolina during 1912 was the largest production that has been reported for the State in the last fifteen years, and amounted to 489,599 pounds of sheet mica, valued at $219,874, and 2,492 short tons of scrap mica, valued at $36,675. In 1911 the production consisted of 454,653 pounds of sheet mica, valued at $187,501, and 2,347 tons of scrap mica, valued at $29,798.

There is given in the following table the approximate value and distribution by counties of the production of mica (both sheet and scrap) for the years 1908-1912, inclusive:

Production of Mica in North Carolina During 1908-1912, by Counties.

County.	1908.	1909.	1910.	1911.	1912.
Ashe	$ 1,200	$ 155	$ 500	$ 4,000	$ 5,300
Buncombe	50			255	531
Cleveland			3,040	1,000	2,300
Haywood	15,000		5,600	4,000	5,732
Jackson	22,600	4,852	12,726	10,875	25,743
McDowell	500		500	400	540
Macon	20,800	45,632	50,300	54,800	53,823
Madison			780	870	1,400
Mitchell	35,620	59,710	93,890	134,745	147,430
Stokes			200	130	200
Transylvania	2,100	5,415	6,140	1,800	2,800
Watauga					100
Yancey	30,000	32,660	56,784	4,200	10,650
Totals	$ 127,870	$ 148,424	$ 230,460	$ 217,075	$ 256,549

The next table gives the value of the total production of mica, including both sheet and scrap, for the years 1900-1912, inclusive:

Production of Mica in North Carolina, 1900-1912.

Year.	Sheet Value.	Scrap Value.	Total Value.
1900	$ 65,200	$ 36,262	$ 101,462
1901	79,849	14,200	94,049
1902	81,653	2,219	83,872
1903	86,300	2,400	88,700
1904	100,724	3,410	104,134
1905	100,900	3,375	104,275
1906	205,756	11,940	217,696
1907	209,956	15,250	225,206
1908	114,540	13,330	127,870
1909	122,246	26,178	148,424
1910	193,223	37,237	230,460
1911	187,496	29,579	217,075
1912	219,874	36,675	256,549

For many years North Carolina has been the largest producer of mica in the United States, and during 1911 and 1912 she continued to hold this record, producing in these two years over two-thirds of the total production of mica in the United States. In order to show the ratio of the production of mica in this State to the total production in the United States, and a comparison of these figures with the value of the imports of mica, there are given in the table below figures covering these points for the years 1903-1912, inclusive:

Production of Mica in the United States and in North Carolina and that Imported Into the United States from 1903-1912.

Year.	Production in N. C., Value.	Production in U. S., Value.	Import, Value.
1903	$ 88,700	$ 143,128	$ 317,969
1904	104,134	120,316	263,714
1905	104,275	178,588	403,756
1906	217,696	274,990	1,042,608
1907	225,206	392,111	952,259
1908	127,870	267,925	266,058
1909	148,424	280,529	618,813
1910	230,460	337,097	724,525
1911	217,075	355,804	502,163
1912	256,549	331,896	748,973

PRICES.

The average price of sheet mica in North Carolina during 1911 was 41 cents per pound; while in 1912 it was 44.9 cents per pound. The average price of sheet mica in the United States during these two years

was 16.4 cents and 33.4 cents respectively. The average price of scrap mica in North Carolina in 1911 was $12.69 per ton; while in 1912 it was $14.72 per ton. The average price of scrap mica in the United States was $12.97 in 1911 and $15.21 in 1912.

PRODUCERS AND OWNERS OF MICA PROPERTIES.

The following were the producers of mica during 1911 and 1912:

T. S. Deiter, Spear, Avery County, and Sugar Grove, Ohio.

W. M. Greer, Spear, Avery County.

J. M. Long, Cullowhee, Jackson County.

W. H. C. Rice, Cashiers, Jackson County.

Eastman Mining Company, care R. W. Garrett, Sylva, Jackson County.

S. T. Bryson & Co., Webster, Jackson County.

James L. Bryson, Franklin, Macon County.

Green-Calloway, Franklin, Macon County.

Jesse N. Law, West Mills, Macon County.

J. R. Ray, West Mills, Macon County.

John E. Rickman, Leatherman or Franklin, Macon County.

A. L. Roberts, Franklin, Macon County, and 644 Katherine Street, Syracuse, New York.

Tippett & Bro., West Mills, N. C.

S. J. Black and Ed. Gay, Bakersville, Mitchell County.

Moses L. Buchanan, Bandana, Mitchell County.

Grindstaff Bros., Bandana or Bakersville, Mitchell County.

J. E. Howell, Bakersville, Mitchell County.

W. N. Jones, Bakersville, Mitchell County.

M. H. Putnam, Bandana, Mitchell County.

Spear Mica Company, care D. Buchanan, Bakersville, Mitchell County.

William M. Watson, Bakersville, Mitchell County.

W. W. Wiseman, Bakersville, Mitchell County.

J. B. Ewing, Boonford, Mitchell County.

D. N. Howell, Bandana, Mitchell County.

S. A. Carpenter, Pyatt, Mitchell County.

Carolina Mineral Company, Penland, N. C.

L. H. Buchanan, Plumtree, Avery County.

W. A. Buchanan, Spear, Mitchell County.

W. B. and D. P. Burleson, Pancake Mine Company, Plumtree, Avery County.
S. J. Johnson, Spruce Pine, Mitchell County.
Jesse McCall, Balsam Grove or Brevard, Transylvania County.
Dr. C. Grimshawe, Montvale, Transylvania County.
Cook & Thompson, Boone, Watauga County.
The Edge & Edge Company, Celo, Yancey County.
R. S. Gibbs & Randolph, Burnsville, Yancey County.
W. C. Green, Burnsville, Yancey County.
J. L. Hall, Newdale, Yancey County.
J. R. Penland, Burnsville, Yancey County.
M. A. Randolph, Celo, Yancey County.
United States Development Company, Columbus, Ohio.
M. P. Letterman, Toledo, Yancey County.
A. M. Patton, Harvard, Yancey County.
W. S. Adams, Biltmore, Jackson County.

MICA BUYERS.

Asheville Mica Company, Asheville, Buncombe County.
J. E. Burleson Mica Company, Spruce Pine, N. C.
L. A. Berry, Spruce Pine, N. C.
Tar Heel Mica Company, Plumtree, N. C.
D. T. Vance, Plumtree, N. C.

QUARTZ.

Besides the quartz that is produced in North Carolina for concrete and other building and paving purposes, there is a certain amount produced each year that is used for an entirely different purpose, such as for flux and for packing towers in connection with the acid chambers. Other uses for which North Carolina quartz should be adapted are in the manufacture of pottery, paints, scouring soaps, and as a wood filler. Quartz suitable for use for pottery purposes can be obtained from iron-bearing minerals. There is a plenty of quartz which can be obtained as a by-product in mica mining, which could be crushed and used in the manufacture of sandpaper.

The only quartz which was produced during 1911 and 1912 was in Gaston County, at the Oliver Mine, near Mount Holly; and the production is included under "Miscellaneous Minerals."

PRODUCTION.

In the table below there is given the production of quartz in North Carolina since the year 1901:

Production of Quartz in North Carolina, 1901-1912.

Year.	Quantity.	Value.
	Tons.	
1901	3,000	$ 7,500
1902	4,500	11,250
1903	29,462	36,827
1904	32,972	36,269
1905	32,648	13,659
1906	20,963	12,578
1907	4,226	1,664
1908		*
1909		*
1910		*
1911		*
1912		*

*Small quantity of quartz included under "Miscellaneous" under general mineral table, p. 16.

BARYTES.

All of the barytes produced in North Carolina was from the mines near Stackhouse, Madison County. The principal producer was the Carolina Barytes Company, and it handles all the barytes mined in that region. This company also handles barytes from Tennessee.

The larger part of its output is the refined barytes, which is floated for pigment purposes.

PRODUCTION.

The production in 1912 was a considerable increase over that of 1911, but on account of there being only one producer, the statistics regarding the production are given under "Miscellaneous Minerals" in the total production of the State. The figures used for the barytes are the value of the crude and not of the refined barytes, which is the condition in which most of it is shipped.

MONAZITE.

The monazite industry in North Carolina, and, for that matter, all over the United States, is at a standstill. The main reason for this is the reduction of the tariff on monazite and also on thorium nitrate, which is made from this mineral. Thorium nitrate is used in the manufacture of mantles for incandescent lighting purposes.

PRODUCTION.

There was a small production of monazite in 1911, and a still smaller one in 1912, but none of the mineral was marketed.

In the table below there is given the production and value of monazite mined in North Carolina from 1893 to 1912, inclusive:

Production of Monazite in North Carolina, 1893-1912.

Year.	Pounds.	Value.	Year.	Pounds.	Value.
1893	130,000	$ 7,600	1903	773,000	$ 58,694
1894	546,855	36,193	1904	685,999	79,438
1895	1,573,000	137,150	1905	894,368	107,324
1896	30,000	1,500	1906	697,275	125,510
1897	44,000	1,980	1907	456,863	54,824
1898	250,776	13,542	1908	310,196	37,224
1899	350,000	20,000	1909	391,068	46,928
1900	908,000	48,805	1910	83,454	10,104
1901	748,736	59,262	1911		
1902	802,000	64,160	1912		

ZIRCON.

Zircon, in commercial quantity, occurs associated with pegmatite in Henderson County, about two miles west of Tuxedo (formerly Zirconia). Two mines were in operation during 1911, one known as the Freeman Mine, which was operated by W. E. Hidden, 25 Orleans Street, Newark, N. J.; and the other known as the Jones Mine, operated by M. C. and C. F. Toms, of Hendersonville. Both of these deposits have been known for many years, but the Freeman Mine has not been operated for the last twenty-four years. The Jones Mine has been operated more or less regularly since 1902, when there was again a commercial demand for zircon, this time for use in the manufacture of the glower in the Nernst lamp. The former use for zircon was in the manufacture of mantles for incandescent lights, but the zirconia was replaced by the thoria, and the demand for this latter mineral at once created the demand for the metallic monazite.

Associated with zircon in the Freeman Mine is the mineral auerlite, a hydrous silicophosphate thorium, containing approximately 7 per cent of thorium oxide. In mining zircon a careful search was made for auerlite, with the result that about a kilogram was obtained from the zircon concentrates during the brief operations of 1911. The zircon and auerlite have high specific gravities, so that they are usually concentrated by washing the decomposed pegmatite matrix.

PRODUCTION.

During 1911 there were 3,208 pounds of zircon produced, which was valued at $802. There was no production reported for 1912.

In the table below there is given the amount and value of zircon mined in North Carolina from 1902 to 1912, inclusive:

Production of Zircon in North Carolina, 1902-1912.

Year.	Pounds.	Value.
1902	2,000	$ 380
1903	3,000	570
1904	1,000	200
1905	8,000	1,600
1906	1,100	248
1907	204	46
1908		
1909	2,000	250
1910		
1911	3,208	802
1912		

TALC AND PYROPHYLLITE.

North Carolina ranks first amongst the States in the production of high-grade talc, such as used for pencils, gas tubes, and electric insulators. There are two minerals which are being mined in North Carolina and put on the market as talc: one being the pure talc, which is a hydrous magnesium silicate; and the other the mineral pyrophyllite, which is a hydrous aluminum silicate. They have very similar physical properties, but the pure talc is of greater value. The talc deposits are all in the western part of the State, principally in Cherokee, Swain, Graham, and Jackson counties; while pyrophyllite is obtained from Moore County, and the east-central portion of the State.

There are talc deposits of considerable extent occurring in Ashe and Alleghany counties which are of sufficient purity to be used for many of the purposes for which Swain County talc is used. On account, however, of the distance of these deposits from the railroad, they have attracted but little attention until the past year, when the railroads began to be constructed into these counties. This should make these deposits available for general use, and they are now being investigated. A certain amount of this material has been quarried each year and cut into slabs and blocks for local use.

PRODUCTION.

In 1911 the production of talc and pyrophyllite in North Carolina was 3,548 short tons, valued at $57,101. In 1912 the production was 3,542 tons, valued at $63,304. This increase in the value of the 1912 production over that of 1911 is due to a greater quantity of talc being produced, which was capable of being made into pencils. Over one-half of the production is pyrophyllite.

As there is very little talc sold in the crude state, the values given are for the production as it was marketed, and it usually represents the manufactured product.

There is given in the table below the condition in which these products were marketed for the past four years:

Production of Talc and Pyrophyllite in North Carolina During 1909, 1910, 1911, and 1912.

Condition in Which Marketed.	1909.		1910.		1911.		1912.	
	Quantity, Short Tons.	Value.	Quantity, Short Tons.	Value.	Quantity, Short Tons.	Value.	Quantity, Short Tons.	Value.
Ground talc for powders, etc.	5,601	$48,499	3,097	$35,094	3,015	$26,564	2,881	$27,851
Talc cut into pencils, gas tips, etc.	130	28,734	114	31,151	103	28,977	148	33,037
Talc sold crude	200	600	576	3,060	330	1,060	458	1,516
Soapstone cut into slabs for chimneys, etc.	25	150	100	500	100	500	55	900
Totals	5,956	$77,983	3,887	$69,805	3,548	$57,101	3,542	$63,304

The table below shows the quantity and value of talc and pyrophyllite produced in North Carolina from 1898 to 1912, inclusive:

Production of Talc and Pyrophyllite in North Carolina, 1898 to 1912, Inclusive.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short Tons.			*Short Tons.*	
1898	1,695	$ 27,320	1906	4,184	$ 66,979
1899	1,817	31,880	1907	4,085	74,347
1900	4,522	75,308	1908	3,564	51,443
1901	5,819	77,974	1909	5,956	77,983
1902	5,239	88,962	1910	3,887	69,805
1903	5,331	76,984	1911	3,548	57,101
1904	3,801	65,483	1912	3,542	63,304
1905	4,035	74,940			

PRECIOUS STONES.

There are many minerals that are included under the head of precious stones, some of which, however, have but little commercial value; while others are extremely rare, and bring a very high price. There are many such minerals found in North Carolina, and each year many of these are mined and put on the market. There is given below a list of these minerals, which come under the head of precious or semiprecious stones that are known to occur in the United States. Those marked with an asterisk have been found in North Carolina:

List of Gems and Gem Minerals Occurring in the United States.†

Diamond.*
Corundum, oriental ruby.*
oriental sapphire.*
oriental emerald.*
asteriated sapphire.*
oriental amethyst.*
oriental topaz.*
Topaz.
Beryl, acquamarine.*
emerald.*
golden.*
blue.*
emerald matrix.*
Garnet, almandine (precious).*
essonite (cinnamon).*
pyrope (Bohemian).*
rhodolite.*
spessartite.
schorlomite (titaniferous).
topazolite.
uvarovite.
Tourmaline, achroite.
Brazilian emerald.
indicolite.
rubellite.
Quartz, rock crystal, "pebble."*
amethyst.*
citrine.*
smoky quartz.*
cairngorm stone (Scotch topaz).
Spanish topaz.*
morion.*
plasma, prase.*
Quartz, rose quartz.*
asteriated quartz, "star quartz."
aventurine.*
quartz, cat's eye.
gold quartz.*
tourmalinated quartz.*
hornblende in quartz.*
gothite in quartz, onegite.
rutilated quartz, sagenite.
fleeches d'amour.
Thetis hairstone.*
agate.*
carnelian.*
chalcedony.*
chrysoprase.*
hydrolite.
moss-agate, mocha stone.*
onyz.
rainbow agate.
royal agate.
sard.
jasper.*
bloodstone (heliotrope).
jasper, agate.*
Lydian stone (basante, touchstone).
novaculite.*
silicified wood.
agatized wood.
jasperized wood.
Opal, opal agate.
fire opal.
lechosos (milky opal).

†This list has been made up from one used by Mr. George F. Kunz, of the U. S. Geological Survey.

Opal, moss opal.
noble (precious).
sun opal.
opaline, opal matrix.
hyalite.*
hydrophane.
wood opal.
opalized wood.
Feldspar, labradorite.*
microline (Amazon-stone).*
oligoclase (sunstone).
orthoclase (moonstone).
obsidian (volcanic glass).
marekanite (mountain mahogany).
moldavite.
Bronzite.*
Pyroxene (diopside).*
Hypersthene.*
Spodumene, hiddenite.*
Nephrite.
Pectolite.
Rhodinite.
Crocidolite.
Iolite (cordierite).*
Sodalite.
Lazurite (lapis lazuli).
Olivine (chrysolite, peridot).*
Phenacite.
Scapolite (wilsonite).
Willemite (troostite).
Zircon.
Cyanite (blue and green).*
Andalusite (macle, chiastolite).
Zoisite (thulite).*
Epidote.*
Chlorastrolite.
Prehnite (zonochlorite).
Thomsonite (mesolite).
Chrondolite.
Dumortierite in quartz.
Serpentine.*
Agalmatolite (figure stone).
Catlinite (pipestone).
Chrysocolla.
Titanite (sphene).*
Pyrite.*
Hematite.*
Rutile.*
nigrine.
Diaspore.
Prosonite.
Malachite.
Azurite.
Rhodocrosite.
Turquoise.
turquoise matrix.
odontolite (bone turquoise).
Variscite.
utahlite.
Amber.
Fire marble (lumachelle).
Fossil coral.

The principal localities where these minerals are found are in Alexander, Burke, Cleveland, Iredell, Jackson, Macon, and Mitchell counties. Recently Warren County, in the eastern part of the State, has been added to this list, on account of the finding of amethysts in quantity in this county.

The following table will give the precious stones that have been found in some quantity in the different counties:

ALEXANDER:
Beryl.
aquamarine.
emerald.
Quartz.
Rutile.
Hiddenite.
BURKE:
Beryl.
aquamarine.
Corundum.

CLEVELAND:
- Beryl.
  - aquamarine.
  - emerald.
- Quartz.

IREDELL:
- Quartz.
  - amethyst.
- Feldspar.
- Zircon.
- Corundum.

JACKSON:
- Corundum.
  - ruby.
  - sapphire.

LINCOLN:
- Quartz.
  - amethyst.

MACON:
- Corundum.
  - ruby.
  - sapphire.
- Beryl.
  - aquamarine.
  - yellow (golden).
- Quartz.
  - amethyst.
  - prase.
- Garnet.
  - rhodolite.

MITCHELL:
- Beryl.
  - aquamarine.
  - emerald.
  - blue.
  - golden.
- Cyanite.
- Garnet.

TRANSYLVANIA:
- Corundum.

WARREN:
- Quartz.
  - amethyst.

YANCEY:
- Beryl.
  - aquamarine.

PRODUCTION.

The gem production for 1911 consisted of amethysts from Macon County; acquamarine and other beryls from Mitchell and Yancey counties; emerald from Cleveland County; quartz from Alexander and Iredell counties; and ruby and sapphire from Macon and Transylvania counties. The total value of these gems was $10,735.

In 1912 the precious stones produced were beryl and quartz in Alexander County; beryl from Burke County; beryl, emerald, and quartz from Cleveland County; amethyst and feldspar from Iredell County; ruby from Jackson County; ruby and sapphire from Macon County; beryl and cyanite from Mitchell County; and amethyst from Warren County. The value of the production was only $5,655. These figures are only approximate, as it is impossible to obtain absolutely accurate figures regarding the production, as those who purchased the rough material kept no record of what had been purchased.

There is given in the table below the production of precious stones in North Carolina for the years 1900-1912, inclusive:

Production of Precious Stones in North Carolina Since 1900.

Year.	Value.
1900	$ 12,020
1901	24,245
1902	5,300
1903	1,525
1904	10,600
1905	3,350
1906	5,000
1907	7,580
1908	*570
1909	*479
1910	*700
1911	*10,735
1912	*5,655

*Estimated by U. S. G. S.

In the annual report of the United States Geological Survey on "The Mineral Resources of the United States" for 1911 and 1912 there are several interesting sketches regarding the occurrence of precious stones in North Carolina, which were prepared by Douglas B. Sterrett, and several of these are given in full in the following pages:

AMETHYST.

The deposits in North Carolina described below are all in the Piedmont Plateau and are associated with the crystalline rocks of that region. Very little work has been done at any of the localities, and prospecting at some of them might result in the discovery of good gems. Fine gem amethyst has already been obtained from some of the localities.

Warren County.—Amethyst occurs at a number of places in Warren County, at some of which fine gem material has been found. An especially promising prospect is located on the Cherry Hill plantation of George W. Alston, at Inez, about 11 miles southeast of Warrenton. There is another promising prospect on the old John Buxton Williams plantation, about 2 miles south of Inez. This place now belongs to Fuller & Person, of Louisburg, N. C. A few specimens have been found on Mrs. Jennie Connell's plantation, about 2 miles southeast of Inez. Good specimens and gems are reported to have been found on the surface and in a pit at Folly Springs, about one-third of a mile southwest of Warrenton.

Warren County lies chiefly within the Piedmont Plateau region of North Carolina along the border of the Coastal Plain. Its elevation ranges from less than 200 feet above sea-level along the rivers to about 500 feet in the less dissected parts of the plateau, in the western portion of the county. In general, the country is nearly flat or gently rolling, with steep hills only along the larger drainage lines. Warrenton is situated on a slightly dissected remnant of the plateau. Inez is located in the fork of one of the elevated ridges, and the country immediately around it has small relief. The Williams and Connell places are on two forks of the same ridge, but are nearer Shocco Creek and accordingly in more broken country.

Amethyst has been found at two places on the Alston plantation, about 200 yards south and about 150 yards southeast of the house. Both prospects are located in a slight hollow, the former in the edge of a small patch of woods and the latter in a cultivated field. At the time of examination the prospect in the woods had been opened by a small pit and a trench about 3 feet deep and 10 feet long on the vein. These openings were about 12 feet apart in a N. 30° W.-S. 30° E. direction from each other. No rock outcrops were seen near the amethyst prospect, but the surface is covered with a light sandy soil containing scattered blocks of granite and pegmatite. The country rock around Inez is chiefly granite, with hornblende schist and mica schist both to the north and to the south for a distance of a few miles. The amethyst occurs in a vein from 1 foot to more than 2 feet thick, striking about with the workings, N. 30° W. This vein consists of irregular seams, streaks, and pockets, with or without amethyst crystals, in decomposed fine granite and pegmatitic granite. Black manganese oxide is associated with the crystals and fills most of the seams and veinlets; in places it occurs as small botryoidal and stalastitic masses. Many of the crystals are partly or entirely coated with this manganese oxide, and it is only by breaking them or scraping off the coating that the quality of the stone can be determined.

The crystals are rather stout and range from a fraction of an inch to 3 inches in diameter. The majority have transparent clear portions, suitable for gems when the color is good. The crystals range from practically colorless amethystine to rich dark purple. They have a distinctive reddish-violet tint and yield brilliant gems. Under artificial light these gems lose nothing of their beauty, but become an even more beautiful lively reddish purple. In many crystals the color is not evenly distributed, but is arranged in layers or streaks parallel to certain crystal faces. One transparent fractured crystal from this local-

ity exhibits a remarkable color variation when viewed in transmitted light. The light transmitted directly through the crystal is a beautiful reddish purple. That transmitted with an interior reflection is a magnificent bluish purple.

About half a bushel of rough crystals were obtained from the two openings. Of these, possibly a quart were suitable for cutting into gems of especially fine quality, 2 quarts could be cut into gems of ordinary quality, and the remainder would probably be suitable only for specimens or might be cut into cheap gems.

The possible extension of this amethyst vein is concealed by its location in the woods. Three small amethysts were found in the light sandy soil of a field about 50 yards S. 40° E. of the pits. Further prospecting might show the continuation of the vein to this point.

No work had been done at the prospect 150 yards southeast of the house, but a quantity of amethystine quartz crystals have been found in the light sandy soil at that place. The crystals are scattered over a belt about 30 feet wide and nearly 100 feet long in a west of north direction. Some of them are quite clear, but only pale purple. Common vein quartz and quartz inclosing plates of titanic iron also occur with the amethyst. An east-west cross-cut trench would probably locate the vein.

Only a few specimens of amethysts were seen on the old John Buxton Williams place, but the quality of these and reports concerning the quantities of fine specimens that had been carried away show that the prospect is a very promising one. No digging has been done, but the crystals have been picked up as specimens by different people during many years, apparently with little thought of their possible value. The amethysts are found on a knoll about a quarter of a mile northwest of the house, outside of the southeast corner of the Williams cemetery. The knoll has been cultivated and is covered with light sandy soil containing angular fragments of fine granite gneiss, quartz, feldspar, and pegmatite composed of smoky quartz, potash feldspar, and mica. Porphyritic hornblende crystals were observed along the bedding planes of some of the fine granite gneiss.

The amethysts are scarce on the surface now, but information furnished by persons who have been visitors at the Williams place shows that they were plentiful some years ago. The specimens found at the time of examination consisted of stout crystals, the largest one measuring 2 inches thick and 2 inches long. The color of the best specimens was very similar to that of the amethyst from the Alston place—that is, characterized by a fine reddish-violet tint. These crystals are clear

and brilliant. The color is segregated in patches or layers, and is in evident relation to the crystal structure. The large crystal mentioned is rather pale purple and incloses a few scattered reddish rutile needles. One specimen is partly incrusted with black manganese oxide, like those at the Alston prospect. The occurrence of amethysts on the surface with the depth of color and transparency of a few of those found is considered an especially good indication of a deposit containing good gem material.

As far as could be learned, no real gem amethyst has been found on Mrs. Jennie Connell's plantation. A few specimens of amethystine quartz have been found in cultivated land north of the house. In the specimens seen the purple occurred in patches through smoky and gray quartz. Rough fragments of smoky and gray quartz are abundant over the ground in the vicinity. Bluish-green fractured beryl has been found in pegmatite a few hundred yards west of the Connell house in a little stream. The possible occurrence of a better grade of beryl suitable for gems had not been determined.

Lincoln County.—There are many occurrences of amethyst in Lincoln County. Besides the few places described below, other localities have been reported. Two prospects were visited on the land of the Misses Rendleman, 2 miles northeast of Iron Station. One of these is about 200 yards south of the old Rendleman home along the east side and on the spur of a small ridge. A few small pits have been dug, but the best specimens observed were loose in the sandy soil of a cultivated field. The crystals were found through a distance of about 100 yards in a north-south direction. The biotite granite gneiss country rock has mostly decomposed to a friable sandy gray saprolite, but around the amethyst prospects it has been hardened by silicification. This process has developed numerous seams and veinlets of quartz crystals, with comb structure through the rock. Some of the larger veinlets carry amethystine quartz and amethyst. Of the crystals found at the time of examination some were pale purple and others a smoky purple. The latter consisted in part of smoky quartz and in part of amethyst, with the different colors generally arranged in layers or zones parallel to the crystal faces. Such specimens furnish good examples of "ghost" or "phantom" crystals. Clear and smoky quartz crystals are also found loose in the soil about 100 feet west of the amethyst lead.

The other and more promising prospect on the Rendleman place is about a quarter of a mile southeast of the house, on a low rocky knoll in a cultivated field. No digging has been done and only surface specimens were seen. The crystals are scattered over an area about

150 feet across, in which no direction of a lead could be determined. The country rock is decomposed granite, but the knoll on which the amethysts are found is covered with rough blocks of silicified granite. Evidently the occurrence of amethyst is connected with this silicification, as at the other prospect, for in some specimens groupings of amethyst crystals are associated with the seams of smaller quartz crystals in the silicified granite. Amethystine quartz crystals measuring 3 inches across were found and specimens more than 1 inch thick were common. A few amethysts of medium dark purple color were seen, but the majority were pale. Some of the crystals are fairly clear and would be suitable for gems if darker colored.

A small prospect was opened for amethysts several years ago on the land of J. P. Lynch, 1¾ miles northeast of Iron Station. The pit is now filled up, but a few pale amethysts were found in the sandy soil at that place and other specimens were seen in the possession of Mr. Lynch. The amethysts were associated with silicified granite, as at the Rendleman prospects. A slab of this rock covered with pale amethysts and quartz crystals, some of them half an inch thick, in the possession of Mr. Lynch, showed that the mineral occurs here lining the walls of a fissure or other cavity. Groups of much larger crystals were found, also. Some of the amethystine quartz crystals are clear and brilliant.

A quantity of smoky quartz crystals and clusters of crystals measuring 2 inches or less in diameter are found on the place of George W. Goodson, about 5 miles north of east of Iron Station. So far as known, no amethysts have been found here.

A few amethystine and colorless quartz crystals were seen on the place of Miss Mary Forney, about 1¼ miles southwest of Denver. The crystals were found loose in the soil of a cultivated field about 250 yards north of the old Forney home. No work has been done, and probably most of the surface crystals have been picked up. Better colored stones than those seen at the time of examination are reported to have been found. The country rock is granite gneiss, decomposed near the surface, inclosing streaks of mica schist. Hornblende gneiss saprolite outcrops near the house and to the west. No vein has been located, and it is probable that the surface specimens came from more than one deposit.

Iredell County.—Amethyst has been found at many localities in Iredell County. Probably the greatest amount of work has been done and the best specimens obtained from the A. C. Cook place, 9 miles southeast of Statesville. No digging has been done at many of the prospects and the only crystals found were loose in the soil. Such pros-

pects were seen on Mrs. M. G. Martin's place, about half a mile west of the Cook mine; on the Burette Brawley place, about 1½ miles south of Cook's; on the J. S. Fisher place, 4½ miles N. 75° W. of Mooresville and 12½ miles south of Statesville; and on the Joe Cornelius place, 6 miles N. 50° W. of Mooresville. Other occurrences have been reported in Iredell County and in Rowan County adjoining, on the land of J. T. Eudy, at Mount Ulla.

The amethysts on the A. C. Cook place were worked about 12 years ago by H. S. Williams, of New York. The prospect had been located by a large quantity of crystals loose in the light, sandy soil of a field. At the time of examination, in 1903, there was a shaft about 12 feet deep with other workings from it badly caved in. The crystals occurred in veinlets and streaks, cutting decomposed pegmatitic granite. A quantity of crystals were left around the workings and a few of gem quality were found washed out of the dirt by rains. It is reported that only a small quantity of amethysts of fairly good color were found, though many crystals were suitable for cutting into less valuable gems. A large quantity of amethystine quartz crystals suitable for specimens and even for cutting into cheap gems was obtained. Some of the darker-purple crystals contained small rutile needles, penetrating them at various angles. The crystals seen reached a maximum of an inch and a half in thickness.

The occurrences on Mrs. M. G. Martin's plantation and on the Burette Brawley plantation are similar. At both places the crystals have been found in coarse, light, sandy soil formed by the decomposition of granite probably inclosing pegmatite. At both places amethystine quartz crystals measuring nearly 2 inches thick and fairly clear were observed. Better specimens were reported to have been found.

The amethyst on the J. S. Fisher plantation has been found scattered over the surface on about an acre of ground some 200 yards northeast of the house. The crystals are loose in the light sandy soil of a cultivated field, and no location or direction of vein has been determined. It is probable that there is more than one vein in the granite saprolite underlying the field. Only pale-purple and colorless quartz crystals were seen at the time of examination.

On the J. Cornelius place amethyst crystals have been found on the surface in a cultivated field. The field is on a north slope and has gray sandy soil with blocks of partly weathered biotite granite gneiss scattered through it. A ledge of granite gneiss outcrops above the amethyst prospect with a strike of N. 65° E. and a dip of 30° SE. The position and probable direction of the vein have not been determined.

The best colored crystals are reported to be found associated with shells or veinlets of limonite that have weathered out on the surface. Only pale purple and colorless crystals were found at the time of examination, but some of these were quite transparent.

Davidson County.—Amethysts have been found at two places on the plantation of N. H. Swicegood, about 5 miles northwest of Linwood and 1 mile south of Taro, in Davidson County. These prospects are about one-fifth of a mile west and northeast of the house, respectively. At the former place a trench 15 feet long and 8 feet deep was dug along a vein striking about S. 25° W. and exposed in the bank of a stream. This work was done in 1909; and several pounds of good crystals are said to have been found. At the prospect northeast of the house a trench about 15 feet long had been made on a vein striking northwest. This work was done some 25 or 30 years ago, and about 300 pounds of amethysts are reported to have been taken out in one day. Only a few pale purple or amethystine quartz crystals were found around the prospects at the time of examination.

The rock in the region around Taro is granite with coarse porphyritic phases. Most of it has weathered at the surface to light sandy soil and saprolite. Decomposed porphyritic phases were encountered in the amethyst prospects. This granite area extends within about 1½ miles of Linwood and from that point to Linwood the country rock is chiefly diorite.

Franklin County.—An investigation was made of the reported occurrence of amethyst near Louisburg, Franklin County, N. C. Amethystine quartz has been found there in two places—on the corner of Nash and Cedar streets in Louisburg and along the public road about 1 mile northeast of the town in front of the cemetery. At Nash and Cedar streets a few small, pale, clear amethystine quartz crystals were found in the light sandy granitic soil. A specimen from the other locality seen in a private collection in Louisburg consisted of a slab 7 inches in diameter and 2 inches thick studded with clear quartz and amethystine quartz crystals as much as two thirds of an inch in thickness. No specimens were found at the time of visit to the locality, but this may have been in part due to improvements on the road covering the original prospect. The rock at this point is evidently granitic, as shown by the light soil and saprolite formed by its decomposition.

A large ledge of pegmatitic quartz extends across Thomas B. Wilder's place on Nash Street in a N. 25°-30° E. direction. This ledge contains many cavities lined with small quartz crystals. It is reported that a few amethysts have been found in some of the cavities.

Wake County.—The occurrence of amethyst at several places in the vicinity of Raleigh, N. C., has been reported at different times by L. A. Fort, of that city. An opportunity was given to the writer to examine one of these deposits on the land of George W. Partin, 5 miles northeast of Raleigh. Here amethystine quartz and pale amethyst crystals are found on the surface of a cultivated upland field. Three or four small prospect pits, now filled up, had been made a few years ago. The deepest of these pits was about 9 feet, at which depth the rock was less decomposed than near the surface and hard to excavate.

The country rock is rather fine-grained biotite granite gneiss, inclosing pegmatitic seams and streaks. The granite has disintegrated to a light sandy soil at the surface and into a friable sandy saprolite to a depth of a few feet below the surface. The amethysts are found in the soil for a distance of about 150 yards in a northeast-southwest direction. Near the prospects they are very abundant, since many that were dug out had not been carried away. Probably 2 or 3 bushels of amethystine quartz crystals could have been collected in half a day from the surface of the ground. In the prospects, Mr. Fort states, the amethyst crystals were found in streaks and seams with a northeast direction, two or three parallel seams occurring within a space of a few feet.

The crystals are only moderately well developed, owing to mutual interference during growth, and nearly all have been somewhat fractured. Some of them have been only slightly chipped and others possess few if any crystal faces. The amethystine quartz and amethyst occur in pieces ranging from those of small size to those 2 or 3 inches across. Aggregates of crystals in parallel growth also occur, some of which consist of both colorless or smoky quartz and amethystine quartz. Many of the crystals are quite clear and transparent, but this is often partly concealed by etched and rough faces. The best specimens found on the surface and in the prospects had been carried off and no dark-purple amethysts were seen. A few stones with sufficient depth of color to warrant cutting were seen, but the gems obtained would not be of the best quality. The abundance of amethystine quartz and amethyst found close to the surface at this locality invites more extended prospecting.

Mr. Fort says he has also found amethyst loose in the soil on the land of the late Capt. F. F. Ellis, 3 miles east of Raleigh.

BERYL.

Alexander County, N. C., is famous for its gem and specimen minerals. Beryl occupies a prominent place among these, and has been found at a number of localities. Emerald and aquamarine varieties

have been mined near Hiddenite, associated with green spodumene (hiddenite) and many other minerals of gem or specimen value. Occasional specimens of gem beryl have been reported from the region west and northwest of Taylorsville, and recent finds of valuable yellow and golden beryl have been made by a small amount of prospecting. Most of the gem localities of Alexander County have been idle for a number of years.

The emerald-hiddenite mine has not been operated since 1907, when the last work was done by the late Cary Wright for the American Gem Mining Syndicate. A description of these operations was given in this report for 1907. The workings are filled with water, and the whole mine site has grown up in a thicket of brush and trees. The writer was fortunate in having Mr. J. E. Turner, foreman of the mine when in operation, point out places of interest. The open cut is about 150 feet long, 20 to 50 feet wide, and 15 to 20 feet deep. The cut has a roughly east-west direction, and was made in red clay saprolite formed by the decomposition of a biotite gneiss country rock. Other pits and shafts were made near the open cut. Several veins were followed down into hard rock by two shafts 40 to 50 feet deep.

The gems occur in more or less parallel veins which are not continuous through many feet. Most of these veins have north of east strike and a high northerly dip. In places the veins run out into seams and in other places they open into pockets lined with crystals of several minerals, such as quartz, calcite, dolomite, muscovite, rutile, black tourmaline, beryl, hiddenite, pyrite, and monazite. A pocket opened in one of the shafts was so large that W. E. Hidden is said to have crawled inside of it. The array of glittering crystals lining this pocket is described as a wonderful sight.

A quantity of fine beryl and hiddenite crystals was obtained from the saprolite removed from the open work. Promising specimens of gem beryl with some hiddenite and many quartz crystals were found in the openings north and west of the mine. Mining operations in the saprolite are easy, but in the fresh biotite gneiss they are difficult. Mr. Turner suggests, and an examination of the locality seems to support his suggestion, that more of the saprolite along the sides of the open cut and at the west end might profitably be removed and washed. If the gently rolling country around the mine were kept under cultivation a good chance would be offered to locate other veins or to determine the trend and possible continuation of the gem formation by a careful search of the fields after rains.

Gem beryl crystals have been found at several places in the region around Hiddenite, and one good hiddenite crystal is reported to have been found about 1 mile east of the mine. These finds, taken into consideration with the widespread occurrence of beautiful crystals of quartz, rutile, and other minerals, such as were found in the veins of the emerald-hiddenite mine, indicate the possible occurrence of other valuable gem deposits in the region.

W. E. Hidden[1] mentions an occurrence of emeralds and hiddenite discovered by W. H. Lackey on the Osborne-Lackey place, one-fifth of a mile northwest of the emerald-hiddenite mine. About 50 emerald crystals, 2 to 7 centimeters long and 2 to 8 millimeters thick, were found. They were transparent but pale colored. One crystal was large and pure enough to cut for gems. The hiddenite crystals were pale colored and of very inferior quality.

Some promising beryl crystals have been found in a prospect on W. H. Warren's place about 1½ miles southeast of Hiddenite. A pit 25 feet long and 15 feet deep was opened in a field where a few surface specimens had been found. A pegmatite vein nearly 8 feet thick with an approximate east and west strike and vertical dip was encountered in a decomposed gneiss formation. The latter is probably biotite gneiss inclosing granite and lies nearly flat. The pegmatite is composed of orthoclase or microcline, gray quartz, and green muscovite, with some biotite, black tourmaline, dark red opaque garnet, and beryl. The beryl occurs in pale greenish or aquamarine, yellow, and nearly golden-colored crystals. The largest crystal seen measured 1 by 1½ inches. Most of the specimens remaining in Mr. Warren's possession are somewhat checked and flawed, but some have small clear portions which are very brilliant.

Beryl crystals are reported to have been found at two places in the fields on the land of Alexander Miller adjoining the Warren place. Transparent, slightly smoky quartz crystals were seen at one of these prospects.

Beryl crystals have been found in two places on the estate of the Miller heirs, 1½ miles east of Hiddenite on the ridge between Davis Creek and Little Yadkin River. Good specimens are reported from this property, and G. F. Kunz,[2] quoting J. A. Stephenson, describes two of them as emeralds "of good color and quite transparent, but very rough on the surface." Since these crystals were found, several prospects have been opened and beryl found in two veins. Quantities of quartz and some fine

[1]Hidden, W. E., Am. Jour. Sci., 3d, Ser., Vol. 29, 1885, pp. 250-251.
[2]History of gems found in North Carolina: Bull. North Carolina Geol. and Econ. Survey, No. 12, 1907, p. 38.

rutile crystals were obtained from the other openings. In one prospect on a steep hillside above Davis Creek good deep aquamarine-colored beryl crystals are reported to have been found in pegmatite. This pegmatite is composed of orthoclase feldspar, greenish muscovite, smoky quartz, and black tourmaline. The other beryl prospect is about 200 yards northwest of the one mentioned and consists of two sets of openings about 100 feet apart. The beryl occurs in pegmatite cutting a decomposed gneiss, probably biotite gneiss, with an easterly strike. Little could be learned of the results of the prospecting.

Some of the beryl prospects northwest of Taylorsville and to the north of All Healing Springs were examined in November, 1912. All Healing Springs are 5 miles N. 83° W. of Taylorsville, or about 6½ miles by road. No work was in progress at the time of examination, and the prospects seen had been made from one to several years before. The following month a little further work was done on some of the prospects and very fine gem material was obtained. Good specimen and gem beryls are reported to have been found in the earlier work, but through misplaced confidence in a tramp miner, nothing was realized on them by the owners, who therefore became discouraged and stopped prospecting. The prospectors are now receiving good prices for their gem beryl, and it is hoped interest in mining for them will be revived.

Especially fine beryl has been obtained from a prospect on Eli Barnes's place, 1¼ miles N. 20° W. of All Healing Springs. This prospect is in a field on the west slope of a small hill about 200 yards northwest of the house. At the time of visit the work consisted of a trench about 20 feet long and 2 to 5 feet deep on a pegmatite vein striking about N. 15° W. The vein is about 4 feet thick and was exposed at both ends and in the bottom of the trench. The country rock is a gneiss, granitic in character, and has decomposed to a granular reddish earth covered by light sandy soil. The pegmatite is composed chiefly of orthoclase or microcline feldspar and quartz, with a little mica, black tourmaline, beryl, and garnet. The best beryl is reported to have been found along a quartz streak or vein from a few inches to 1 foot thick in the pegmatite. This quartz vein pinched out in the bottom of the trench but was exposed in the north end. The feldspar occurs in masses and rough crystals several inches thick inclosing rough gray crystals and masses of quartz and other minerals. Some of the quartz is slightly cloudy or translucent dark gray. The black tourmaline occurs in the common rounded triangular crystals measuring up to an inch in thickness. Fragments of dark-red semigem garnet crystals more than an inch thick were observed. The beryl crystals occur in both the feldspar

and the quartz, and some are closely associated with black tourmaline. Only inferior specimens of colorless, white, yellow, and greenish-yellow beryl crystals were found around the prospect, but a few better specimens were held by the owners. One of these was a beautiful light, clear straw-yellow crystal which has since been cut into two perfect gems weighing 1.5 and 0.4 metric carats. These stones are very brilliant but slightly pale for the best gems. Some of the light-colored and colorless beryls would yield very brilliant gems.

Since this prospect was examined in November, 1912, a beautiful clear yellow beryl crystal weighing 70.5 grams or 352.5 metric carats, has been found. This crystal has been fractured at the ends and measures in its present form 25 by 30.5 millimeters thick and 33 to 48 millimeters long. There are three larger cracks across the crystal and other smaller flaws. The prism faces have rhombic etchings. Much of the beryl is limpid and clear and of fine gem quality. It has a light golden or rich honey-yellow color.

Good beryl is reported to have been found in the prospect of Thomas Barnes, 2 miles N. 30° W. of All Healing Springs, on a spur extending east from a mountain ridge. The prospect has been opened by four pits and open cuts in a distance of about 125 feet in a N. 15° W. direction across the ridge. The deepest pit was about 10 feet. The country rock is mica schist and gneiss containing cyanite and garnet. These rocks strike about east and west with a vertical dip. The beryl occurs in pegmatite, cutting the country rock with a strike of N. 15° W. and a dip of about 70° W. The pegmatite is about 3 feet thick and incloses a quartz streak or vein 1 foot thick parallel with its walls through the whole distance opened. A quantity of mica was found along this quartz vein in the work, and for this mineral the prospect was in part opened. Mica crystals 6 inches in diameter were found, but the quality and quantity could scarcely be considered of commercial value. Golden, yellow, greenish, and colorless beryl crystals were found. The beryl occurs along the contact of the quartz streak with the feldspathic part of the pegmatite chiefly in granular to coarsely crushed glassy phases of the quartz. Black tourmaline occurs in the pegmatite, and some is associated with the beryl in the quartz. The largest beryl crystal found is reported to have been about 3 inches thick and 18 inches long. A section of this about 3 inches long was seen at Nathan Barnes's house. It was light-colored, mostly opaque, and not of gem quality. Small yellow to golden beryl crystals with fine clear portions were seen, indicating the occurrence of good gem material in the vein.

The presence of another pegmatite 15 feet west of the deep pit was shown in a small prospect pit.

At the prospect on James Chapman's place, formerly owned by Mike Swim, 1¾ miles N. 15° E. of All Healing Springs, a pit, now nearly filled up, 10 or 12 feet deep, was made on a pegmatite deposit. A vein striking about N. 25° W. was found inclosed in a gneiss of granitic nature. The presence of hard fine-grained biotite gneiss débris around the dump causes uncertainty as to whether the country rock may not be biotite gneiss injected by granite and not granite gneiss. A couple of hundred yards west of the prospect the country rock is cyanite schist. The pegmatite incloses a quartz streak about 1 foot thick. This quartz is mostly glassy and crystallized and some is smoky brown. The feldspar occurs in rather large masses, and a rough crystal with a cleavage face 8 inches across was seen on the dump. Some graphic intergrowths of quartz and feldspar occur. In some of the blocks seen on the dump pegmatite appears to grade into coarse granite. Black tourmaline and muscovite and biotite mica were also present. Good golden and yellow beryl are reported to have been found in this prospect.

Golden and yellow beryl are also reported to have been found in a prospect on John Webster's place, about 1¼ miles N. 50° E. of All Healing Springs. This prospect has been opened by three small pits in a N. 15° W. direction, on a hillside. The deposit could be worked by a drift on the vein from the north, probably more than 30 feet lower than the present pits. The country rock is mica schist injected with granite. The beryls were found in pegmatite associated with a streak of glassy smoky quartz. The feldspar of the pegmatite occurs in masses which yield cleavage faces several inches across. Muscovite, biotite, black tourmaline, and beryl are accessory minerals of the pegmatite.

A distorted crystal of beryl measuring about 20 by 35 by 42 millimeters was found by Felix Webster in a field on George Teague's land a few hundred yards north of John Webster's prospect. This crystal has a pale-yellow color and is rather badly fractured. It contains clear portions sufficiently large to cut a few gems of less than one-half carat weight.

Specimens of beryl crystals from Cleveland County, with notes on their occurrence, were shown to the writer by Mr. George L. English, of Shelby, N. C. The prospect is on the Whisnant place, on the west side of Broad River, near Hollybush. It was opened by Messrs. Whisnant and Morrison, of Hollybush, by a shaft about 30 feet deep.. The vein is pegmatite with considerable black tourmaline scattered through it. Many pounds of rough beryl crystals were found, and among them were a few crystals of gem quality. The latter were light-yellow and greenish with portions sufficiently free from flaws to cut. A gem of nearly two carats weight cut from a pale-yellow crystal was very brilliant and pretty.

EMERALD.

Emerald is ranked among the few really precious stones and by some people is considered the most valuable. It has been prized from early times because of its beauty and rarity. The number of localities where good gems have been found is few, and some of those once known have been forgotten. The following notes on foreign localities are taken from a book by Max Bauer.[1] Emeralds found with the mummies of Egypt probably came from the mountains along the west coast of the Red Sea in Upper Egypt, where ancient workings were discovered during the nineteenth century. Mines in the Salzburg Alps are said to have been worked intermittently for emeralds since the time of the Romans to the present. The world's principal supply of emeralds has come from South America. They were first brought to Europe from Peru by the Spaniards in the sixteenth century. None are now found in that country, and it is thought that the Peruvians obtained them from Colombia. Three mines were worked by the Spaniards in Colombia. Later two of these were lost, and for many years the only mines worked were those near Muzo. Recently the lost mines of Somondoco were found on the east side of the Andes Mountains at an elevation of about 9,000 feet above sea level.

Fine emeralds have been found in the Ural Mountains about 60 miles east of Ekaterinburg. This locality was discovered in 1830 by a peasant, who noticed the stones among the roots of a tree torn up by the wind. A few other European localities are known. Emeralds have been found at two localities in Australia. The most promising one is near the township of Emmaville in New South Wales.

Several localities in the United States have yielded emeralds, but the best specimens have come from North Carolina. In Maine a few stones have been found at Topsham and a pale-colored stone at Newry. A few crystals are reported to have been found at Haddam, Conn.

In North Carolina three localities are now known where good emeralds occur. The first of these to be discovered was in Alexander County in 1875 by J. A. D. Stephenson, of Statesville, N. C. This locality was later developed into the emerald-hiddenite mine near the present railroad station, Hiddenite. The second locality was discovered in 1894 by J. L. Rorison and D. A. Bowman on Crabtree Mountain in Mitchell County. Both of these deposits were developed on a fairly large scale and a few fine gems were obtained from each. Progress at the third emerald locality described below has been given in these reports for 1909 and 1910. The deposit is on the land of W. B. Turner, 4¾ miles S. 30° W. of

[1] Precious stones [translation by L. J. Spencer]; Charles Griffin & Co., Ltd., London, 1904, pp. 309 et seq.

Shelby, near the east bank of First Broad River, in Cleveland County. Some 15 years ago two emeralds were found loose in the soil on the Borders farm about 1 mile east of Mr. Turner's. Further search failed to discover more gems and prospecting was given up. Subsequent investigation indicates that these stones were transported by residents or farm hands on the Turner plantation to the adjoining place during friendly intercourse of long standing.

The attention of the writer was called to the discovery on the Turner place by Mr. George L. English, of Shelby, to whom acknowledgment is due for many courtesies and much information. The first visit to the prospect was made in December, 1909, at which time no digging had been done, but about a dozen emeralds had been found loose in the soil of a cotton field. The locality is in a rather roughly dissected portion of the Piedmont Plateau, such as is generally found along the larger creeks and rivers. The elevation is about 680 feet above sea level, or about 30 feet higher than First Broad River near by. The higher ridges of the Piedmont Plateau in the neighboring country are about 800 to 850 feet above sea level. The crystals have come from an area of about 100 feet by 25 feet on a hillside of moderate slope to the northwest. The slope is toward the river on the west about 150 yards and toward a small stream entering the river from the northeast. The field in which the emeralds were found had been cultivated and they were exposed by plowing and by the washing of rains.

Prospecting up to December, 1911, consisted of the digging of several pits and trenches, some of which had been filled up. The largest working was a cross-cut trench over 100 feet long and from 2 to 14 feet deep. This work was done by Mr. Turner and Mr. English during 1909, 1910, and the first part of 1911. The property was optioned and leased by Lovat Fraser, of New York, and prospected during the last part of 1911 and the first part of 1912. In the spring of 1912 it was purchased by Messrs. Fraser and E. P. Earle, of New York, and will be extensively prospected. Excavations have been carried deeper by Mr. Fraser than when last examined by the writer. Promising finds of emeralds have been made at each working, but these discoveries have been followed by periods of uncertainty as to the continuity of the vein.

The crystals found loose in the cotton field had a fine dark-green color, but were somewhat checked and flawed, and some contained silky internal markings. The largest of these emeralds and the best specimen so far found measured about 1 inch by three-fourths of an inch by half an inch. It was about half of a crystal split parallel with the length. This piece has been cut into about 20 gems, the largest of which

is a faceted stone weighing about 3 carats. This stone has been described as having an excellent deep-green color and as being particularly beautiful at night. It has almost no visible flaws, but is slightly foggy in strong daylight. The other gems cut from this crystal are of similar quality, but some contain more flaws. The other stones found on the surface ranged down to less than a carat in weight in the rough and most of them were deep green. Some were nearly whole crystals and others were fragments of crystals. All were rather strongly etched and striated. Very pretty gems have been cut from smaller fragments of crystals found on the surface. Some of these were sold at rather low prices before their true value was realized and the proceeds were devoted to prospecting. These gems brought $10 to $30 per carat. A lot of 11 of these emeralds cut "en cabochon," weighing about 9 carats, have been mounted in a small necklace and would bring several hundred dollars at retail prices.

Gems cut from emeralds removed from the vein have also proved of good quality, but are probably not quite so deep in color as those found on the surface. The crystals from the vein range in size from that of a portion of a large needle to a broken specimen measuring seven-eighths of an inch thick and nearly 5 inches long. Some of these emeralds have fairly well developed crystal faces, but the majority are roughly striated and pitted, though retaining a rude hexagonal outline. In some specimens no trace of crystal form remains. As usual with emeralds, only small pieces are free of flaws and imperfections. Many crystals contain slight checks across their length, and in some the flaws lie at all angles. Some stones are cloudy and others contain fine internal striations or silkiness. Stones in which this is pronounced give a fine cat's-eye effect when tipped to and fro. Small crystals have been found that will cut practically flawless stones up to one-half carat in weight, and even in such small gems a flawless emerald of good color is very rare. The quality of many of the emeralds can not be judged from their external appearance, as the exterior is badly striated and by reflection of the light makes the stone appear both of lighter color and more imperfect than it really is. The average of the emeralds from the Turner mine has been pronounced equal in quality to the average run of Colombian emeralds, and New York dealers are beginning to recognize the beauty of the North Carolina gem.

Mr. Fraser has furnished an estimate of the total quantity of emeralds obtained from the Turner mine along with notes on a few of the gems cut from vein material. The exact weight could not be given, as some of the stones were cut and sold before the property came into

his charge. In all about 2,700 carats of rough stones have been found. So far over 200 carats of gems have been cut and to judge from the yield in cutting, about 700 carats of cut gems ought to be obtained from the 2,700 carats of rough material. From the rough material selected as fit to cut, the yield of gems has been about one-third. The cut gems have been valued at $5 to $200 per carat wholesale, and a moderate estimate of the average value would be $15 per carat.

One lot of 27 cut stones ranging up to over a carat in weight, seen by the writer, contained some fine stones. One of these with a table cut, weighing 0.83 carat, was a fine, clear, dark-green gem with only a slight flaw. This stone has been variously estimated by lapidaries and dealers as worth from $125 to $200. Reputable lapidaries valued it at about $200 per carat. Other stones in this lot are worth up to $90 per carat, but some would probably not bring over $10 to $25 per carat. Mr. Fraser mentions a lot of smaller gems, chiefly about one-fourth of a carat in weight, but some at least half a carat, which are "brilliant, very clear and clean, and of good green color." One oblong faceted stone of about 1 carat has a good color, is clear, and is not badly flawed. It is considered one of the best gems found. Another fairly clear and fairly brilliant gem weighing 2¼ carats and having a good color has been classed by a lapidary as one of the most important gems. An attractive gem is a long tapering drop weighing 20 carats. It has an excellent color and is clear in spots.

Before taking up the discussion of the geologic occurrence of the emerald a few notes on its nature and modes of occurrence at other localities will be given for comparison with the new locality.

Emerald is a variety of the mineral beryl. Beryl is a silicate of aluminum and beryllium containing a small per cent of water. Small quantities of other elements may be present and in some stones influence the color. Thus, beryl containing cæsium is generally colorless and very brilliant; the presence of lithium produces the pink beryl, and chromium the emerald. Other color varieties of beryl are aquamarine, blue beryl, and golden beryl. A small per cent of chromium oxide is sufficient to impart a rich emerald-green to beryl. According to Bauer,[1] an analysis by F. Wöhler of Colombian emerald gave 0.186 per cent chromium oxide.

Beryl crystallizes in the hexagonal system and commonly occurs in six-sided prismatic crystals terminated by the base with or without other faces. In emerald simply the prism faces and base are the most common. Beryl is nearly always found crystallized, even when "frozen" in hard rock. Crystals that have developed in cavities are in some cases beautifully developed.

The following notes on the occurrence of emeralds in Colombia, Egypt, the Ural Mountains, and Salzburg Alps are taken from Max Bauer.*

In Colombia emeralds occur in calcite veins and nests in dark bituminous limestone. The limestone overlies red sandstone and clay slate of Cretaceous age. The calcite may be dark with bituminous matter or clear like Iceland spar. Associated with the emeralds are fine quartz crystals, both colorless and green, pyrite, green gypsum, black dolomite, and parasite, a fluo-carbonate of cerium, and other rare metals. In Upper Egypt the emeralds occur in dark mica schist interfoliated with talc schist, and at one locality these rocks contain also augite and hornblende. The occurrence in the Ural Mountains is said to be very similar. In the Salzburg Alps the matrix is described as somewhat similar and consists of finely granular dark brown and greenish mica schist interfoliated with chlorite and hornblende schist.

The emeralds found in Maine and Connecticut were associated with pegmatite.

At the emerald-hiddenite mine in Alexander County, N. C., emeralds have been found in pockets and cavities in veins cutting biotite gneiss. The gneiss has been strongly compressed and folded while in a plastic condition. In the neighborhood of the veins it has been highly silicified by the addition of much quartz which, along with muscovite, rutile, pyrite, etc., has replaced the biotite and feldspar. The minerals filling the veins are quartz, calcite, dolomite, muscovite, rutile, black tourmaline, pyrite, chalcopyrite, monazite, aquamarine, emerald, and hiddenite. There are numerous veins near the mine which carry common beryl, aquamarine, and quartz, but emeralds and hiddenite were found in only a few veins. Hiddenite, the emerald-green spodumene, was the chief mineral of value obtained from this locality, though some fine emerald crystals were found.

According to Arthur Keith,† at the Crabtree Mountain locality in Mitchell County, N. C., the emeralds occur in pegmatite inclosed in mica gneiss. A few feet east of the vein is a body of hornblende gneiss. The pegmatite has a northerly strike and dips 45°-50° E. It is composed mainly of feldspar, quartz, black tourmaline, and beryl, and incloses horses of biotite-tourmaline schist. The emeralds occur sparingly through the pegmatite, but are more plentiful in the upper 8 inches under the hanging wall where many are in small bunches and horses of schist. The gems are "frozen" in the pegmatite. Small crys-

*Precious stones (translation by L. J. Spencer), Charles Griffin & Co., Ltd., London, 1904.

†Mount Mitchell folio (No. 124), Geol. Atlas U. S., U. S. Geol. Survey, 1905.

tals of emerald are abundant, and the color of many of them is good emerald-green. Some are pale-colored or yellowish. Occasionally gems of value have been found. Much of the pegmatite matrix containing white feldspar, gray quartz, black tourmaline, and green emeralds has been cut under the name of emerald matrix. Some of this material is very pretty.

The occurrence of emeralds at the Turner mine is similar in many respects to that at some other localities, but there are here certain associated rocks which seem to belong naturally with the occurrence of emeralds that are not present in other deposits.

The rocks of this portion of the Piedmont Plateau are principally gneisses and schists of Archean age, cut by masses of later granite, diorite, and other rocks. In the region around the emerald prospect the types of rock are varied. There are mica, garnet, cyanite, graphite, and hornblende gneisses and schists cut by granite, pegmatite, diorite, gabbro, and other ferromagnesian rocks. Another rock which answers the description of garnetiferous quartz diorite occurs abundantly at certain horizons in the gneiss. The strike of the rock formations is variable between east-west and north-south where the strata are tilted, but over large areas they are essentially flat, with many small, rather gentle folds.

Warping of the rocks with larger sharp folds occurs and produces abrupt changes in outcrop, so that mapping the formations is difficult. Another difficulty is the apparent metamorphism of ferromagnesian rocks to rocks of less basic composition, and of granite to more basic composition by reaction between the two at the time of the intrusion of the granite. In the descriptions of the rocks associated with the emerald deposit in these reports for 1909 and 1910 tentative names were given to some rocks, as the material available for examination was so badly weathered. Less altered specimens obtained from greater depth have made more accurate determinations possible. Thus, rock called amphibolite, and amphibolite after pyroxenite, proves to be hornblende hypersthenite and is so called below. A number of varieties of basic rocks occur, but all may be placed in one general class.

The most common type is hornblende hypersthenite-peridotite, and of this there are numerous outcrops. In some occurrences olivine is lacking or scarce, and the rock may be called hornblende hypersthenite. The minerals composing these rocks, as determined by microscopic examination, are pale-green hornblende, light-brownish hypersthene, olivine, augite, biotite, pleonaste, magnetite, and a little sulphide. Hornblende and hypersthene are present in all occurrences, but one or all of

olivine, augite, biotite, and pleonaste were not observed in some specimens. The hypersthene and olivine occur in poikilitic crystals, in some specimens of large size. In some places weathering has changed hypersthene to bastite, hornblende to chlorite, and added limonite stains. The result is a rock resembling chloritic soapstone. On disintegration and decomposition these rocks break down to a dark greenish-brown lumpy soil.

Gabbro occurs at several localities and is of two kinds, common and olivine gabbro. The former exhibits a partial diabasic texture in thin section. The constituent minerals determined microscopically in one specimen are labradorite, hornblende, part original and part formed from pyroxene, augite, hypersthene, biotite, magnetite, apatite, and pyrrhotite. Olivine gabbro is associated with the hornblende hypersthenite-peridotite, and the two rocks are probably segregations from the same magma. Some specimens contain such minerals as to make it difficult to determine whether the rock should be called olivine gabbro or hornblende hypersthenite-peridotite. The olivine gabbro weathers to a soil very similar to that formed by the peridotite. Spheroidal bowlders are generally left over in the outcrops.

Diorite and hornblende gneiss are common rocks of the region. Microscopic examination of sections reveal hornblende, andesine, biotite, iron ore, apatite, zircon, and, in some specimens, quartz. On weathering the dioritic rocks form dark-brown clay soils.

The granite of this region is medium-grained biotite granite. Pegmatitic phases are associated with it, especially near the contact with other rocks, and in some places the small bodies may equally be called pegmatite or granite. On disintegration the granite breaks down to a light sandy soil.

The relations between the granite and the basic rocks are interesting. Besides the types of basic rocks mentioned, there are gradations from them into granite by the presence of granite minerals. This gradation is present where gabbro, olivine gabbro, and hypersthenite-peridotite are inclosed in granite. Thus, a specimen from a spheroidal bowlder of weathering near a gabbro and granite contact contained andesine or labradorite, hornblende after pyroxene, biotite, and considerable quartz along with iron ore, apatite, and pyrrhotite. The true gabbro from this body has more calcic feldspar and ferromagnesian minerals with no quartz. A spheroidal bowlder from a similar contact at the emerald mine contained hornblende, biotite, labradorite, quartz, magnetite, and apatite. Diorite contacts with granite show a similar gradation by the presence of quartz.

The ages of all the different rocks have not been determined. The mica and garnet gneisses and schists are of Archean age and belong to the Carolina gneiss, as designated by Keith in the geologic folios on the Southern Appalachian region. The diorite and associated hornblende gneiss and schist are also Archean and belong to the Roan gneiss. The gabbro, olivine gabbro, and hornblende hypersthenite-peridotite rocks are probably of later age. They were intruded into the other gneisses and schist before the granite, and Keith thinks much of the granite of this region is probably of post-Carboniferous age. The intrusion of the granite before the complete consolidation of the basic rock magmas would make easier an explanation of the apparent mutual absorption described above that has taken place between the two. If the basic rocks are considered much older than the granite, the reaction between the two and absorption by the granite appear to offer a better explanation than would be offered by magmatic differentiation.

Pegmatite probably representing later stages of activity of the granite magmas have filled openings and fissures in the rocks. Some of these are in the basic rocks, and it is in such fillings that the emeralds have been found on the Turner place. Several pegmatite veins have been uncovered during the prospecting, but so far emeralds have been found in only one of them. The basic rocks are olivine gabbro and hornblende hypersthenite, with transitional phases between them. Diorite lies to the west of these, and all have been surrounded and intruded by biotite granite.

The emerald-bearing vein has an irregular strike approximating east and west with a high dip north. It is medium to coarse grained, and is composed of quartz and feldspar, part of which, at least, is albite, with some black tourmaline sprinkled through it and an occasional emerald or green beryl crystal. The crystallization of the minerals of the pegmatite is not good, but a few partly developed crystals are found in small, irregular miarolitic cavities. Crystals found in these cavities are quartz (colorless and smoky), albite, feldspar, black tourmaline, and a little beryl. The cavities in the pegmatite are partly filled with reddish-brown, greasy-feeling clay, and the same material along with limonite stains has permeated joints and seams through the pegmatite. The feldspar of the pegmatite has partly decomposed in places, so that the rock breaks down rather easily. Some of the emerald crystals are firmly attached to other minerals, and some are loose and may be obtained by washing the semidecomposed pegmatite. At first many small fragments and crystals of emeralds were found in this way, but later gem emerald was also found in place in the rock.

The crystallization of the quartz and feldspar so far found in the pegmatite vein is not so perfect as that in the veins once worked for beryl and hiddenite at Hiddenite, N. C. The albite assumes the form of rough crystals and of aggregations of stout crystals, though not of the clevelandite type common in many gem-bearing pegmatites. The quartz occurs in crystals of average perfection, and in many of the specimens exhibits trapezohedral faces indicating a right-hand character. Some of the quartz is nearly colorless and other is smoky. One crystal of quartz examined is penetrated by numerous fine light-colored needles of actinolite. The emerald crystals are simple hexagonal crystals of beryl with the prism faces and base. Many of them are deeply striated and etched, especially on the prism faces. Other crystals have internal striations or irregularly shaped tubes extending through their length. Some of these tubes are of considerable size compared with the crystal inclosing them and have been filled with clay or iron stains. The finer tubes appear as silky striations in the crystals.

Veins containing quartz crystals occur in the same formation as the emerald-bearing pegmatite. Some of the quartz crystals from these veins are fairly well developed and clear; others contain inclusions of fine needles of actinolite and cut into very pretty gems. Veins of quartz crystals occur over a large area in this region and yield some fine specimens. Large crystals containing liquid with bubbles have been found about a mile northwest of the emerald mine in a similar rock formation. Black tourmaline is plentiful both at the emerald mine and in other places.

Determinations of chromium oxide were made in four rocks from the emerald region by R. C. Wells, of the United States Geological Survey. Hornblende hypersthenite wall rock for the emerald vein carried 0.16 per cent Cr_2O_3; olivine gabbro, also close to the emerald vein, contained 0.17 per cent Cr_2O_3; hornblende-hypersthene-auguite peridotite from about three-fourths of a mile east of north of the emerald mine carried 0.19 per cent Cr_2O_3; and diorite from near the emerald mine carried 0.04 per cent Cr_2O_3.

Pale-greenish, yellowish, and gray beryl crystals have been found in pegmatite cutting granite and mica schist and gneiss in this region, but the only emerald deposit discovered is where such pegmatite cuts a chromium-bearing rock. This association of emerald-bearing pegmatite with a chromiferous basic rock seems a most natural one. A theory of origin of the emeralds at the Turner mine may be thus briefly stated:

Chromium-bearing basic rock was intruded by granite magma either before or after final solidification of the basic rock. There was a par-

tial absorption of the latter by the granite magma and some of the constituents of the basic rock were taken into solution. Pegmatite veins, in which distinct crystals were only partly developed, formed during the cooling of the rocks. The elements necessary for the formation of beryl were present in the magmatic solutions producing pegmatite, as in some other places in the region. Chromium oxide necessary to impart a color to the emerald was obtained by the action of solutions on the basic rock. A curious coincidence is the fact that the per cent of Cr_2O_3 in the basic rocks at the Turner mine is about the same as that found in emerald from Colombia, by T. Wöhler, as mentioned above.

Should the theory of origin outlined above be essentially correct, prospecting in areas where similar rock associations occur might locate other deposits of emeralds. Of course, it should not be expected that every pegmatite associated with the rocks mentioned will carry emerald, for beryl has been found with only a very small proportion of the large number of pegmatites occurring in the region. Besides chromium-bearing basic rock and pegmatite, the presence of the elements of beryl in the original pegmatite-producing solutions would be necessary. Outcrops of basic rocks similar to those at the Turner mine occur in a number of localities in the region south of Shelby, and some of these are near if not associated with granite. Pegmatites cut many of these basic rock masses, and over some of the outcrops crystals of black tourmaline, quartz, and quartz-inclosing actinolite are plentiful, as at the Turner mine. In some of these areas the associations are very similar to the emerald locality. The occurrence of the basic rocks is not always easily recognized, since weathering has been extensive. In such places a study of the soil will often give the clue desired.

Mining and prospecting were continued at the Old Plantation mine through 1912 and are still in progress (April, 1913). Deposits of emeralds were opened in July and August, 1912, and 269 carats of irregularly shaped pieces and fragments of crystals were obtained. These lots of emeralds consisted of both clear and partly cloudy gem material, the color of some of which was a fine deep green.

Some emeralds of very fine quality have been obtained along with those of ordinary grade. The best stones have the deep grass or emerald green color characteristic of that gem, with only the average amount of flaws or defects usual in the fine-grade material. In other stones the color may be fine and deep, but defects, such as cracks, cloudiness, or silky inclusions, are prominent. Still other gems of paler color but containing only very slight flaws, if any, are found. The total yield of selected rough emeralds in 1912 is placed at 2,969 carats, with an esti-

mated value of $12,875. This material should yield about 800 carats of cut gems with a greatly increased value, probably $25 a carat or more. Retail values for some of the better emeralds range up to $200 a carat, and one fine stone weighing a fraction over 2 carats was sold for $200 at wholesale value.

Prospecting and development of the deposit and separation of emeralds from the matrix have been carried on under the direction of Lovat Fraser, of New York. The deposit lies in a hill with moderate slope northwest and north, and has been opened by numerous pits, crosscut trenches, and open cuts within a distance of about 100 yards in an east and west direction. The principal development is the cotton-boll pit at the place of original discovery. In November, 1912, this consisted of an open cut of irregular shape about 75 feet long in an east and west direction and 10 to 25 feet deep, with a shaft or pit several feet deeper in the bottom. A tunnel 15 feet long was run in from the east end of the cut and a crosscut trench 160 feet long extended north from the bottom of the pit for prospecting, drainage, and to facilitate mining. Other pits and trenches, both east and west, have been made close to the cotton-boll pit. A track about 250 feet long with a mine car is used in the big crosscut trench to carry vein material and waste rock to their respective dumps near a branch north of the mine. Later developments have been reported by Mr. Fraser, which consist of a deep pit about 90 feet south of east and a deep crosscut trench about 200 feet east of the cotton-boll pit.

QUARTZ.

Quartz crystals of varied types are widespread over Alexander County, N. C. Some are simple crystals of clear colorless or smoky quality; others are of value as specimens because of the development of a large number of unusual crystal faces. Other crystals contain inclusions of rutile needles and other minerals or of water with movable bubbles. The quartz crystals range from small size to those of 50 pounds weight. An abundance of crystals were obtained during the operation of the emerald-hiddenite mine, and some of those obtained from one pocket have been described by W. E. Hidden.[1] They were remarkable for the inclusions of large cavities partly filled with water and bubbles. Some of the Alexander County smoky and colorless quartz crystals have been cut for gem purposes, and those inclosing rutile needles have yielded especially good sagenite or rutilated quartz gems.

Two prospects for quartz crystals were visited during the course of an examination of beryl prospects in Alexander County in November,

[1] On a phenomenal pocket of quartz crystals: Trans. New York Acad. Sci., March, 1882.

1912. One of these was on the land of Thomas Barnes, 2 miles N. 32° W. of All Healing Springs and about 250 yards west of the prospect on the same property described under beryl. The quartz prospect is near the summit of a knob on the same mountain ridge as the beryl prospect. Two small pits were dug on a vein of glassy quartz, 2 to 5 inches thick, cutting gneiss composed of mica, garnet, and cyanite schist. Beautiful smoky quartz crystals were found in pockets along this vein. The crystals range in size up to 2 inches in thickness and over 3 inches in length. They are transparent and have a fine smoky-brownish color. A few crystals were obtained in sufficiently perfect condition to have value as specimens, but many were chipped by rough handling.

The other prospect is on the place of Moses Barnes, 2 miles N. 20° W. of All Healing Springs. The prospect is in the side of a hollow or ravine and has been opened by a small irregular-shaped shaft 18 feet deep. The country rock is a mica schist inclosing granite. The crystals follow a glassy quartz vein 3 to 6 inches thick, striking north and south, with a vertical dip. The crystals range from small, nearly perfect ones to stones nearly 6 inches thick. Aggregates of muscovite mica crystals are inclosed in or partly penetrate some of the quartz crystals. The quartz varies from clear or slightly smoky to fairly dark smoky in color. Some of the crystals would yield good cabinet specimens if carefully removed from the vein.

BIRTH STONES.

The American National Retail Jewelers' Association adopted a standard list of birth-month stones at its meeting in Kansas City, in August, 1912. The changes made in the lists ordinarily used were slight and consisted chiefly of the addition of alternative stones. The following is the list* that was adopted:

Birth-month stones.

January	Garnet.
February	Amethyst.
March	Bloodstone or aquamarine.
April	Diamond.
May	Emerald.
June	Pearl or moonstone.
July	Ruby.
August	Sardonyx or peridot.
September	Sapphire.
October	Opal or tourmaline.
November	Topaz.
December	Turquoise or lapis lazuli.

*Jewelers' Circular Weekly, Aug. 14, 1912.

MINERAL WATERS.

There is included under the head of "Mineral Waters" any spring or well water that is sold in bulk or packages for table or medicinal use. Water sold as public supplies are excluded from these statistics, as are also natural waters which have been greatly changed either by the addition of mineral substances or from concentration by evaporation. The figures given below regarding the value of mineral waters are those furnished by the spring owners, and represent as nearly as possible the amount received for the water exclusive of the price charged for the containers.

PRODUCTION.

The production of mineral water in North Carolina for 1911 and 1912 is given below:

1911.

There was an increase in the output of mineral water in 1911 as compared with the year 1910, the sales reported amounting to 231,510 gallons, valued at $31,108, as compared with 143,007 gallons, valued at $21,389 in 1910, an increase of 88,500 gallons or nearly 62 per cent in quantity, and of $9,719 or about 45 per cent in value. The number of springs reporting sales in 1911 were 16, and the greater portion of the water sold was for medicinal use, the average selling price of the mineral water being 13 cents per gallon. At ten of the springs there were resort hotels which are accommodating about 1,500 patrons. At five of the springs the water is used for bathing. The following springs reported sales for 1911:

All Healing Springs, Alkalithia Springs, Alexander County.
Barium Rock Spring, Barium Springs, Iredell County.
Buckhorn Lithia Spring, Bullock, Granville County.
Derita Mineral Spring, near Derita, Mecklenburg County.
Haywood White Sulphur Springs, Waynesville, Haywood County.
Huckleberry Spring, Durham, Durham County.
Jackson Springs, Jackson Springs, Moore County.
Mida Spring, near Huntersville, Mecklenburg County.
Moores Springs, Moores Springs, Stokes County.
Mount Vernon Springs, Mount Vernon Springs, Chatham County.
Panacea Springs, Littleton, Halifax County.
Seven Springs, Seven Springs, Wayne County.
Shelby Lithia Spring, Shelby, Cleveland County.
Sherrill Mineral Spring, near Harrisburg, Cabarrus County.
Smith Lithia Spring, Oxford, Granville County.
Vade Mecum Spring, Vade Mecum, Stokes County.

1912.

The same sixteen springs that reported sales of mineral water in 1911 also reported sales in 1912. The total sales, however, in 1912 were considerably less than the previous year, amounting to 144,708 gallons, valued at $22,385, as compared with 231,510 gallons, valued at $31,108. This is a loss of 86,802 gallons or 37.49 per cent in quantity and of $8,723 or 28 per cent in value. The price received for the mineral water in 1912 was an average of 15 cents per gallon or 2 cents more than was received during 1911.

The table below gives the quantity and value of mineral waters which were put on the market for 1901-1912, inclusive:

Production of Mineral Waters in North Carolina Since 1901.

Year.	Amount, Gallons.	Value.
1901	375,700	$ 42,167
1902	104,400	18,795
1903	83,100	13,085
1904	145,800	21,902
1905	201,000	38,755
1906	158,680	31,413
1907	193,479	40,302
1908	171,395	27,163
1909	128,171	20,558
1910	143,007	21,389
1911	231,510	31,108
1912	144,708	22,385

PRODUCERS.

The following are owners of mineral water properties:

O. F. Pool, Taylorsville, Alexander County, *All Healing Springs.*

A. S. Caldwell, Barium Springs, Iredell County.

Buckhorn Lithia Water Company, Henderson, Vance County.

Connelly Mineral Springs and Hotel Company, Connelly Springs, Burke County.

B. H. Martin and A. H. Alexander, Derita, R. F. D. No. 14, Mecklenburg County.

B. J. Sloan, Waynesville, Haywood County, *Haywood White Sulphur Springs.*

J. H. Rumbaugh, Hot Springs, Madison County.

J. J. Riley Estate, 302 Milton Avenue, Durham, N. C., *Huckleberry Springs,* Granville County.

J. L. and Frank Page, Jackson Springs, Moore County.

Midas Spring Water Company, 205 S. Poplar Street, Charlotte, N. C.

J. T. Moore & Son, Moores Springs, Stokes County.

Mount Vernon Mineral Water Company, *Mount Vernon Springs,* Ore Hill, R. F. D., Chatham County.

Panacea Springs Company, Inc., Littleton, Halifax County.

J. J. Ivey, Seven Springs, Wayne County.

Shelby Lithia Water Company, Shelby, Cleveland County.

N. J. Sherrill, Manager, Charlotte, Mecklenburg County.

R. T. Smith, Manager, Oxford, Granville County.

Vade Mecum Springs Company, Vade Mecum, Stokes County.

COAL.

PRODUCTION.

In 1911 North Carolina produced a small amount of coal, which was the first output reported for the State since 1905, when the Cumnock Mines of Chatham County were shut down. The production of 1912 which amounted to 120 tons, valued at $240, was obtained from the Foushee place, Moore County, and is owned and was operated by Mr. A. J. Jones of Glendon. The other coal field of North Carolina, known as the Dan River Coal Field, was thoroughly exploited; and, as stated in the report for the year 1910, there is no reason to expect to find commercial coal beds in that district.

There is given in the table below the production of coal in North Carolina since 1890:

Coal Production in North Carolina from 1890 to 1912.

Year.	Quantity.	Year.	Quantity.
1890	10,262	1902	23,000
1891	20,355	1903	17,309
1892	6,679	1904	7,000
1893	17,000	1905	1,557
1894	16,900	1906	------
1895	24,900	1907	------
1896	7,813	1908	------
1897	21,280	1909	------
1898	11,495	1910	------
1899	26,896	1911	------
1900	17,734	1912	120
1901	12,000		

The report by Mr. R. W. Stone on the "Dan River Coal Field" was published as Bulletin No. 471-B of the United States Geological Survey, and is reprinted here.

COAL ON DAN RIVER, NORTH CAROLINA.

By R. W. Stone.

INTRODUCTION.

On maps of the coal fields of the United States there is shown in the northern part of North Carolina a narrow belt in the Piedmont Plateau which is called the Dan River coal field. Although this small field has been known for nearly a century, there is no record of coal produced from it.

Triassic sedimentary rocks extend from a point just north of the Virginia line southwestward along Dan River through Leaksville, Madison, and Walnut Cove, to Germanton. High-grade coal has been found at several places in a bed ranging from a few inches to a foot thick. This fact and the belief among people in the district that black shale is a sign of coal, and if followed far enough under cover will lead to coal, have caused more or less extensive prospecting of the outcrop at favorable places. A bed of bright black flaky carbonaceous shale, several feet thick, near Walnut Cove, has excited some interest from its promising appearance; but as it usually carries over 40 per cent ash, it has no present value as fuel.

About 1907 a citizen of Winston-Salem, N. C., spent several thousand dollars in sinking a shaft on this carbonaceous bed and in a diamond-drill hole at Walnut Cove. His failure to find a workable bed led to a request for information from the United States Geological Survey as to the probability of the existence of coal in merchantable quantity near Walnut Cove. In order to comply with this request, the writer spent six weeks in the field during March and April, 1910. In the course of an examination of the coal resources, a stadia traverse of the main road from Germanton to Leaksville at 1:31,680 scale was made by means of a 15-inch planetable. Mapping was not carried farther because coal had not been found east of Leaksville. Coal prospects also were located by stadia traverse. The plan of the town of Spray was reduced from a drawing loaned by Mr. B. F. Mebane. The accompanying map (Pl. IX) is a one-half reduction of the original work.

All known exposures of coal in prospects and natural or artificial outcrops were examined, and a number of pits were reopened. J. Luther Mitchell, of Walnut Cove, superintended the excavating and assisted as rodman.

This examination led to the conclusion that there is no reason for expecting to find commercially valuable coal beds in the Dan River district. The beds of semianthracite are local lenses of small lateral extent and only a few inches thick. The thick bed of carbonaceous shale is valueless. It is useless, therefore, to expend money and energy in this field with the hope of developing a coal mine. A Survey press bulletin stating these results was given to the newspapers, May 31, 1910.

GEOGRAPHY.

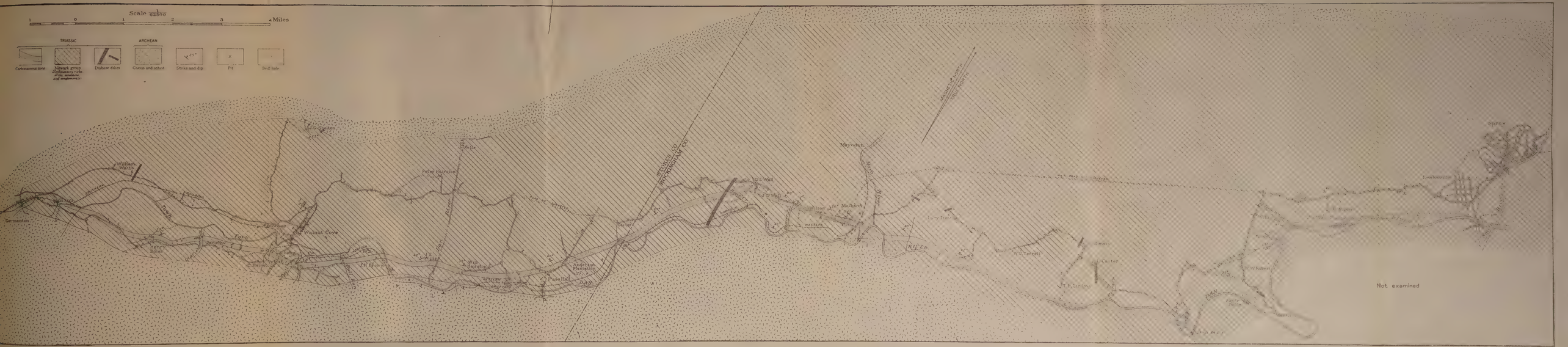
The Dan River coal field lies along Dan River and Town Fork in Rockingham and Stokes counties, N. C. The principal tributaries of Dan River in this field are Smith River near Leaksville and Spray, Mayo River, which joins the Dan at Madison, and Town Fork, which flows through Germanton and Walnut Cove.

The Danville and Western Railway terminus is at Leaksville. The Norfolk and Western Railway follows Dan River and Town Fork from Madison to Walnut Cove. The Sanford and Mount Airy branch of the Southern Railway crosses this field from Walnut Cove to Germanton.

Germanton, with a population of about 150, is situated at the southwestern extremity of the coal field. Walnut Cove, at the crossing of the Norfolk and Western and Southern railways, has 480 people. Stokesburg, which is mentioned in a number of reports on this district, is a small settlement on the hill opposite Walnut Cove, and has neither a postoffice nor a railway station. Madison has a population of 1,033 and Mayodan has 874. Leaksville is an old town near the mouth of Smith River with a population of 1,127, and Spray, which is 1 mile north of Leaksville, has about 2,000 people, mostly employed in the cotton mills.

Elevations above sea at railroad stations are as follows: Germanton, 676 feet; Walnut Cove (Southern Railway), 624 feet; Pinehall, 579 feet; Madison, 559 feet; Mayodan, 556 feet; Leaksville, 700 feet.

The general region in which the Triassic rocks occur is a dissected plateau of moderate relief. It is mainly an agricultural district, the principal crops being corn, cotton and tobacco. Cotton mills at Mayodan and Spray are the chief manufacturing plants, being located where water power is available. A good site not utilized at present is at the falls on Dan River 4 miles northeast of Walnut Cove. These "falls" are a series of rapids where the river crosses the contact between the gneiss and the Triassic rocks and descends about 15 feet in 300 yards.



GEOLOGIC MAP OF THE DAN RIVER COAL FIELD, NORTH CAROLINA

By R. W. Stone.

GEOLOGY.

Only three geologic divisions occur in this field—Triassic sedimentary rocks (Newark group), including the coal and black shale beds; Archean gneiss, which completely surrounds the sedimentary rocks; and diabase dikes.

ARCHEAN GNEISS.

The oldest of the three formations in the Dan River valley is Archean gneiss. It is the common country rock in this part of the State and surrounds the coal-bearing formation. No attempt was made to distinguish between Carolina and Roan gneiss, both of which are present. The Carolina gneiss is commonly composed of mica and garnet gneisses and schists, whereas the typical mineral constituent of Roan gneiss is hornblende. These rocks range in color from light to dark gray. Some of the gneiss and schist is fine grained and is composed of several distinguishing minerals, as biotite, muscovite, and graphite, besides fine grains of quartz and other minerals; other rocks are composed of the same minerals in coarse grains and flakes. The presence of much pegmatitic material is a characteristic feature of the Carolina gneiss. Very commonly the gneiss and schist are banded with or cut at various angles by streaks of pegmatitic or granitic material.

The Archean rocks have undergone extreme regional metamorphism, with accompanying folding and faulting. The mashing and the recrystallization of the Carolina and Roan gneisses have been so extensive that all of the original texture has been obliterated by the intense metamorphism.

Rock weathering is so deep on the Piedmont Plateau that good outcrops are the exception. The gneiss, on partial disintegration and decomposition, commonly forms a gravelly soil with a red clayey matrix.

TRIASSIC SYSTEM.

NEWARK GROUP.

The sedimentary rocks of the Dan River coal field are of the same age as those of the Richmond Basin in Virginia. The stratigraphy is similar to that of the Deep River area, conglomerates at the base being overlain by coal-bearing shale, which is succeeded by thick sandstone and fine conglomerate toward the top. Little available knowledge exists concerning the details of the bedding. The concealment of the bedrock by a thick mantle of residual soil makes it almost impossible to obtain a detailed section of the whole of the Newark group.

The coal field is commonly described as extending from Cascade, Va., to Germanton, N. C., and being from 3 to 7 miles wide. It is possible that the width of the Triassic sedimentary rocks may be close to 7 miles between Leaksville and Madison. At Madison it is nearer 5 miles. By stadia measurement the writer found the width of the outcrop of Triassic rocks at Walnut Cove to be about 3 1-3 miles. The dip of the rocks averages over 20° NW. If there is no repetition by faulting, the thickness of the beds here exposed is nearly 8,000 feet. This estimate is based on the following data:

Section of Triassic sedimentary rocks at Walnut Cove.

	Feet.
From base of the sedimentary rocks to base of carbonaceous shale, 1,600 feet, average dip 40°	1,220
Approximate thickness of carbonaceous shale zone	250
From top of carbonaceous shale zone to contact with gneiss, approximately 15,000 feet, average dip 25°	6,340
	7,810

The belt of sedimentary rocks tapers from Walnut Cove to Germanton and pinches out at the latter locality. The lowest sedimentary rock at Walnut Cove is red shaly sandstone, which rests on gneiss. The contact is near the 16 milepost on the Norfolk and Western Railway, about a mile south of the depot. Above this red bed is a series of yellow sandstone and shale beds with a few red sandy and shaly beds interspersed. About 1,000 feet from the base is a sandstone which is in part conglomeratic, containing small pebbles of quartz.

This conglomerate, which lies just below the carbonaceous shale, is well exposed back of Cabel Hairston's house in the highway crossing Sandy Branch a mile south of Walnut Cove and also in the road about 2 miles east of Germanton and north of the fork of the road. This rock is an arkose sandstone made conglomeratic by the inclusion of fragments of mica, schist, and feldspar and subangular pebbles of quartz up to an inch in length. The general color of the fresh rock is gray mottled with white. The conglomerate was not found at Leaksville, toward the northeast end of the field.

Between the beds of conglomerate along the road 1½ miles east of Germanton silicified trunks of trees are numerous. The roots and bark of some of these old trees are changed to lignite. The trunks have been flattened and a few of the largest exceed 2 feet in diameter. Silicified wood occurs also about 1¼ miles southeast of Walnut Cove in the road which crosses Bull Run half a mile above its mouth, and also on the hill slope one-fourth mile west of the brick plant at Pinehall. In each

place it is at the same horizon, just below the carbonaceous zone. At Pinehall the underlying conglomerate is exposed along the railroad.

Above the conglomerate and silicified wood horizon there is red sandstone, in part variegated, which terminates above in the shale of the carbonaceous zone.

The carbonaceous zone consists of yellow sandy shale and shaly sandstone interspersed with thin beds of black fissile shale. The entire zone is not over 250 feet thick. A 326-foot section measured in a cut on the Southern Railway on the east side of Mill Creek half a mile east of Walnut Cove probably includes the entire zone. From the bottom of the lowest black shale to the top of the highest is 227 feet.

Section of carbonaceous shale zone in Southern Railway cut at Walnut Cove, N. C.

	Feet.
Sandstone:	
Gray, hard	5
Greenish, shaly	12
Hard, gray	2
Shale, yellow, sandy, fossil shells top and base	5
Sandstone, gray, hard, lenticular	1
Shale, greenish, clayey and sandy	42
Sandstone, green, nodular, micaceous	2
Shale and sandstone, greenish	15
Shale, black, fissile	2
Shale and sandstone, greenish	11
Shale, black, fissile	1
Shale and sandstone, greenish	10
Sandstone, greenish, micaceous, hackly face	14
Shale:	
Yellowish, sandy, fissile	9
Black, carbonaceous	3
Sandstone and shale, greenish, thin bedded, soft	31
Sandstone, greenish, soft	7
Shale, black, fissile	1
Sandstone, greenish, soft, shaly in middle	17
Shale, black, fissile	2
Sandstone, greenish, soft	10
Shale, black, fissile	1
Sandstone and shale, greenish	3
Shale:	
Black, fissile	3
Greenish, sandy	8
Black, fissile	5
Green, clayey and sandy	3
Black, fissile	1
Green, sandy,	26
Black, fissile	8

Shale:	Feet.
Greenish, clayey and sandy	30
Black, fissile	2
Gray, sandy	9
Black, fissile	1
Grayish green, sandy	7
Black fissile	2
Gray to green, sandy	15
	326

Another section of some of these beds was measured in the Norfolk and Western Railway cut half a mile southwest of the depot at Walnut Cove.

Section of carbonaceous shale zone southwest of Walnut Cove, N. C.

Sandstone ledges in path to mineral spring.	
Sandstone:	Feet.
Yellow, soft, shaly	10
Gray, hard	1
Shale, yellow, clayey, fossil shells at top	12
Sandstone, gray, soft	1
Shale, yellow, clayey	11
Sandstone, yellow, soft, rather massive	4
Shale, yellow, sandy	4
Sandstone, yellow, soft, lowest layer hard	6
Shale:	
Black, fissile, and brown, crumpled	2
Yellow, sandy	4
Sandstone:	
Yellow, shaly	6
Green, micaceous, hackly face	16
Shale:	
Yellow, sandy, part micaceous, fish scales	3
Black, fissile, and drab, clayey	1
Shale and sandstone, yellow, soft, clayey, micaceous	24
Shale, black fissile	1
Sandstone, yellow, shaly	8
Shale:	
Yellow, clayey	4
Black and drab, fissile	1
Concealed	12
Shale, black, fissile	2
Concealed	40
Shale and sandstone	10
Coal and carbonaceous shale in Evans pits	4
	186

This section includes about 137 feet of the upper part of the carbonaceous zone. The lower portion is not well enough exposed to measure.

In the Southern Railway cut at Walnut Cove 13 beds of black fissile shale were counted, as shown in the section on page 119, and on the J. E. Willis place, near the mouth of the Town Fork, the same number of black shale beds was found in the plantation road. A characteristic feature of these beds is the common occurrence of fish scales and of small cylindrical bodies about an inch long which fit loosely in cavities in the rock and which crumble readily. They are believed to be coprolites.

The sedimentary rocks lying above the carbonaceous zone are red and yellow shale and sandstone, with conglomerate at one or more horizons. They have not been measured and the details are not known. At Walnut Cove the horizontal distance from the top of the coaly belt across these beds to the gneiss on the north is about 2¾ miles and at Madison it is about 4 miles. One place where conglomerate was seen above the coal zone is 2 miles north of Walnut Cove in a zone of purple sandy shale. The conglomerate has a coarse matrix, possibly derived from gneiss, as it contains abundant feldspar and mica, and besides pebbles of quartz and feldspar, cobbles of pink pegmatite, reddish quartzite, and green schist and gneiss.

Fossil animals and plants collected at a number of places from the black shale of the carbonaceous zone prove the Triassic age of these beds. The following determinations were made by T. W. Stanton concerning collections made by the writer and submitted to him for examination:

The fossils are all of Triassic age and the invertebrates in most of the lots belong to the phyllopod crustacean genus Estheria. Several species have been described from these beds and referred to the genus Posidonia, but these have all been referred to a single species Estheria by T. Rupert Jones, who has reviewed them. In one lot there are numerous specimens of a minute ostracod crustacean, which Jones has described as *Candona? rogersii*. The following are the determinations in the lots collected:

In highway at Neal place, 2½ miles west of Walnut Cove:
Estheria ovata (Lea).

Black shale, common near Walnut Cove:
Scales of ganoid fishes.

East end of Southern Railway trestle over Mill Creek, Walnut Cove:
Estheria ovata (Lea).

Norfolk and Western Railway cut one-third of a mile south of Walnut Cove:
Estheria ovata (Lea).
Candona? rogersii (Jones).

Fossil plants from these same black shale beds were submitted to F. H. Knowlton, who has determined them as follows:

In highway at Neal place, 2½ miles west of Walnut Cove:
Fragments of a cycad leaf, possibly of Macrotæniopteris or Pterophyllum, but too fragmentary to identify positively.
Well at Dr. Jones's residence, Walnut Cove:
Ctenophyllum grandifolium Fontaine.
W. W. Roberts's well, 5 miles west of Leaksville:
Cheirolepis muensteri (Schenk) Schimper.
Actinopteris? sp. Obscure leaf.
Equisetum? sp. Mere fragment.

The conifer named above is well known in the Triassic of eastern North America.

Prof. Ebenezer Emmons* reports finding the bones of saurians similar to the alligator which now inhabits the southern part of the State. He discovered vertebræ and fragments of ribs embedded in the black shale near Leaksville, at a point near the bridge over Smith River. As this discovery was made about sixty years ago, before the village of Spray had been built, and as the highway bridge at that time was very near the location of the present bridge, it is presumed by the writer that a more accurate description of the place where these bones were found would be at Spray near the bridge over Smith River. This part of the formation is in the midst of red sandstone and about 5,000 feet from the outcrop of the carbonaceous zone. As the dip of the beds here is 40° to 41°, the position of the bones is about 3,000 feet above the black shale.

In or near Germanton Emmons found many small bones, more or less broken, and a femur and tibia embedded in sandstone just below the carbonaceous shale. These bones were in all probability parts of the skeleton of a saurian.

DIABASE.

Diabase is the latest intrusive rock known in this part of the State and is probably of Triassic age. It occurs in dikes which commonly cut across the strike and dip of all the older formations, filling a series of fissures which have a general northwest to north strike. The diabase is a dense hard rock of dark-green to black color, composed chiefly of augite and plagioclase feldspar with small amounts of olivine, biotite, and magnetite. The outcrop is generally marked by characteristic spheroidal bowlders scattered over the surface. The diabase dikes range from a few inches up to 100 feet or so in thickness.

*Emmons, Ebenezer, Geological report of the midland counties of North Carolina: Geol. Survey North Carolina, 1856, pp. 309, 318, 322.

The largest dike found by the writer in this field is in a railroad cut on the bank of Dan River 3 miles west of Madison and halfway between the twenty-seventh and twenty-eighth mileposts on the Norfolk and Western Railway. It has a north-south course, stands vertical, and is 130 feet wide. The rock is black, fine-grained, and in thin section under the microscope shows typical diabase structure. It is composed of lath-shaped plagioclase feldspar with augite packed in the interstices. There is also some olivine, partly altered to serpentine, with apatite, magnetite, and other accessory minerals. A similar dike, presumed to be the continuation of that in the railroad cut, outcrops in the highway half a mile west of the house of G. L. Wall, at a road fork 2 miles west of Madison.

A diabase dike of similar dark color but finer grain was found at the William Watts place, 2 miles northeast of Germanton. Its position was recognized by a train of large bowlders in the field east of the house. The course of the dike is nearly north-south.

Very much like these dikes is a sill exposed in Mayo River at Avalon, just above Mayodan. Microscopic examination of a thin section cut from this rock shows that it is composed of lath-shaped plagioclase with augite and quartz in the interstices.

Other diabase dikes and sills were found in the highway about 1⅓ miles northeast of the depot at Madison; 1 mile farther east along this road and 300 yards northwest of the home of Mrs. Lucy Trent; at the J. H. Lewis place, 5 miles east of Madison; 1,000 feet east of R. L. Carter's, 2½ miles west of Suttle Bridge; and along a road three-fourths of a mile northeast of Eagle Falls. Their dimensions and extent were not determined.

STRUCTURE.

The structure of the Triassic area on Dan River is known only in a general way. This area is 35 to 40 miles long and 3 to 7 miles wide, tapering at both ends. The rocks all dip to the northwest at angles ranging from 15° to 50°. Along the southeast side of the field the sedimentary rocks rest unconformably on Archean gneiss, but on the northwest side they dip toward the gneiss. The rocks near the latter contact are exposed at the falls of Dan River, about 4 miles northeast of Walnut Cove. Here the Triassic beds dip 14° to 23° NW., and planes of foliation in the gneiss in the banks of the pond above the falls dip 30° SE. The strike is practically the same in both formations, N. 60° E. Rocks at the contact can be seen also about 4 miles northwest of Walnut Cove, between J. R. Shelton's and a spring at the John Reed place.

The highest Triassic beds are thin red shaly grit of small pebbles in a micaceous sand. They dip at an angle of 25° NW. against mica schist.

The high westward inclination of the Triassic rocks across the whole field, and especially close to their junction with the crystalline rocks, suggests a marginal fault, and from this it is concluded that the Triassic beds in the Dan River area are the remnant of a fault block of unknown extent. The greater part of the fault block has been carried away by erosion, and this part remains because the faulting carried it below the horizon of a subsequent base level.

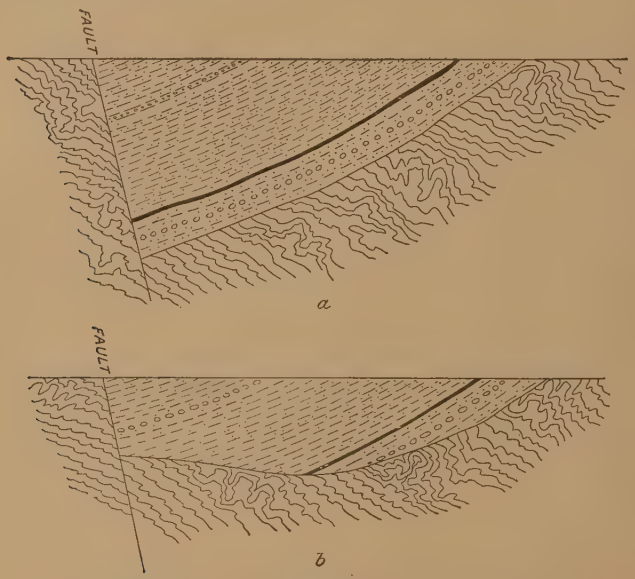


FIG. 5. Hypothetical cross sections through Walnut Cove, N. C.

The hypothetical cross section in Fig. 5, *a*, is drawn to scale, the depth of the beds along the fault plane being assumed as approximately 7,800 feet, the calculated thickness given on page 118. The dip of the lower conglomerate is approximately 40°; of the carbonaceous shale, 31°; near the center of the field, 25°; and on the northwest side, 15° to 20°.

Further detailed work in this field may show whether the structure of this Triassic block is, as indicated in Fig. 5, *a*, a simple fault block with a total thickness of about 7,800 feet of sedimentary rocks, or whether some other condition exists.

Another hypothesis regarding this structure, as suggested in Fig. 5, *b*, is that these Triassic sediments were deposited in a basin with a receding shore line due to slow tilting. Thus the beds would be deposited farther and farther back from the original shore, and the carbonaceous shale toward the bottom of the basin would terminate against the old shore only part way across the present basin and would not extend as far as the fault.

The position of the beds in the Dan River field, as shown, is the direct opposite of that on Deep River, where the beds all dip southeast. It has been suggested that these two coal fields are the opposite sides of a "graben," or sunken fault block, but when the distance between them and the frequency of folds in this general region is considered it seems more probable that one or more folds or faults may have intervened and the relation between the two coal fields may not be so close.

Folding within the Triassic beds is conspicuous in the region of the big loop of Dan River, 4 to 6 miles southwest of Leaksville. The position of the outcrop of carbonaceous shale, part of which is hidden by alluvium, was observed at too few points to determine its exact course. The peculiar loop of the river, an irregularity without counterpart in this field, where the course of the sedimentary rocks is regular, suggests some abrupt change in the strike of the soft rocks which the river follows. Near Eagle Falls black shales occur at several points out of line, striking and dipping in various directions. Whether they extend farther out the loop than is shown on the map is not known, but that they do is regarded as possible.

Considering the purely economic purpose of the investigation, when it had been found that there was no coal bed of value in this vicinity the writer did not feel justified in spending time and funds in working out the structural details at this place. Further study naturally would lead to mapping the upper and lower boundaries of the Triassic directly north and south of the disturbance here mentioned to determine whether there is an offset in the contact with the gneiss corresponding with that of the carbonaceous shale. Lack of time did not permit the study of these questions and others of equal interest in regard to the structure, and they remain for whoever eventually maps the geology of this area in detail.

COAL.

PREVIOUS REPORTS.

The earliest record of the existence of coal in this part of North Carolina is a single sentence written in November, 1824, in which Denison Olmsted asserts the occurrence of coal in Rockingham County.[1]

[1]Olmsted, Denison, Geology of part of the western counties of North Carolina, 1825, p. 20.

This must mean the coal along Dan River, for that is the only place in the county where coal might occur. The next reference is by the same writer in 1827,[1] in which he makes the following statement:

A bed of pit coal occurs only two or three hundred yards from the northern bank of Dan River, 3 miles by land below the Eagle Falls. It is seen on the side of a hill that faces the east, dipping to the northwest at an angle of about 20°, and is so situated as to afford the greatest facilities for mining. As to the quality of the coal, it is of a kind which is free from bituminous matter and which burns without flame, but my observations were too limited, and the specimens that I was able to obtain were too imperfect to enable me to speak with confidence respecting its value. Veins of coaly matter resembling lampblack are met with still farther south, not far from Germanton, and the black slate rocks of the whole district are impregnated in a greater or less degree with the same.

This coal described as 3 miles below Eagle Falls is that which was mined during the Civil War on the old Wade plantation now occupied by J. P. Wilson.

The next reference is by Ebenezer Emmons, who in 1852 spoke of the Dan River coal in his report[2] of the geologic survey of North Carolina. In a subsequent report on the midland counties of North Carolina,[3] published in 1856, he gives some short stratigraphic sections of the rocks immediately adjacent to and including the black shale in which the coal is found and describes in detail the fossils of this section. James MacFarlane in 1873, in a report on the coal fields of North Carolina,[4] quoted some of Emmons's statements, and Heinrich, in a paper on the Mesozoic of Virginia,[5] published in 1878, mentions the Mesozoic as extending along Dan River and into Virginia about 8 miles to a point a little east of Cascade village. In 1884 W. B. Rogers, State Geologist of Virginia, gave some attention to the North Carolina coal localities, notwithstanding the fact that they lie beyond the geographic boundaries of his State, in order to get evidence as to the possibility of the occurrence of coal in similar areas within the boundaries of Virginia. In his report[6] he makes the following statement concerning a certain coal deposit in the Dan River area:

The dark color and rather carbonaceous character of these shales has given rise to the opinion that they contain a valuable seam of coal, for the explora-

[1]Olmsted, Denison, Report on the geology of North Carolina, 1827, p. 126.
[2]Emmons, Ebenezer, Report of Prof. Emmons on his geological survey of North Carolina: Ex. Doc. No. 13, North Carolina Gen. Assem., sess. 1852.
[3]Emmons, Ebenezer, Geological report of the midland counties of North Carolina, 1856, 351 pp. (Reviewed in Am. Jour. Sci., 2d ser., vol. 24, 1857, pp. 427-429.)
[4]MacFarlane, James, Coal regions of North America, their topography, geology, and development, 1873, pp. 516-528.
[5]Heinrich, O. J., The Mesozoic formation in Virginia: Trans. Am. Inst. Min. Eng., vol. 6, 1878, pp. 227-274.
[6]Rogers, W. B., Geology of the Virginias, 1884, pp. 324-325.

tion of which operations have, it is understood, been actually commenced. At Linsey's, 3 miles above Leaksville, in shales of the same character which are here observed frequently to alternate with red and gray sandstones, two shafts have been sunk in search of coal, and a small seam of dark carbonaceous matter has been explored, consisting of alternating layers of coal and slate, the aggregate thickness of the former probably not exceeding 1 foot. It is a nonbituminous coal, generally compact and lustrous, and bearing a striking resemblance to a very common variety of the Pennsylvania anthracite. Its composition in the 100 grains is as follows:

Carbon	83.12
Volatile matter	7.76
Ash	9.12

* * * * * * *

I may therefore mention as the result of these inquiries that from the facts observed no reasonable hope can be deduced of finding either at the points referred to or in the neighboring portions of the formation in Virginia any seam of sufficient thickness and extent to prove of real economical importance. The existence of carbonaceous layers containing small portions of coal, sometimes of great purity, at various points in the range of this formation, far from being improbable, is what might naturally be expected from the views already stated as to the origin of the materials composing the middle secondary strata in general. But looking to the fact already stated, that the rocks in question belong undoubtedly to a later epoch than that of the great coal formation of this and other countries, an epoch marked by the deposition of strata distinguished for their barrenness of vegetable as well as animal remains, no encouragement to expensive enterprises of research can be derived from these merely local and as it were accidental accumulations of vegetable matter.

The most comprehensive report on the Dan River coal field is that made by Henry M. Chance to the State Board of Agriculture of North Carolina in the year 1885. In this report[1] he describes the coal and coaly beds found at a number of localities, including the vicinity of Leaksville and Walnut Cove, or Stokesburg. Four sentences are quoted from his conclusion:

> It should be stated at the outset that this district cannot truthfully be termed a "coal field," as the coal occurs merely as sporadic deposits of quite limited extent and is too thin, irregular, and uncertain to be of any commercial value. . . . From all the facts gathered in this examination of the Dan River district it seems certain that it will be entirely useless to expect to find workable coal beds. The small seams of coal that do exist are local deposits, without thickness, purity, or continuity. It is therefore idle to pursue the subject further.

This statement was so discouraging that after being published the State Board of Agriculture is said to have withdrawn the report and

[1] Chance, H. M., Report on an exploration of the coal fields of North Carolina made for the State Board of Agriculture, 1885, pp. 62-66.

destroyed the larger part of the edition. In 1887 another description was published by the North Carolina Board of Agriculture and quoted by the United States Geological Survey.[1] This account was based largely on the statements of H. B. Robson, an Englishman, who spent several years in the field prospecting for workable coal beds. It was asserted that Robson had found the coal beds from 3 to 7 feet thick and at one place nearly 9 feet thick; some anthracite and some "soft" coal as he termed it. He predicted that when developments had been carried farther there would be added to the resources of North Carolina at least 40,000,000 tons of accessible coal.

Reports of later years by other authors are compilations of previously published statements, including brief mention of localities and quoting analyses of coals found in this region. A statement by J. A. Holmes, State Geologist of North Carolina, published in 1893,[2] describes the results of deep drilling done at the expense of the State Survey, as follows:

> Early in 1891 the coal deposits near Walnut Cove, Stokes County, were attracting considerable attention, and it was considered advisable to investigate them. As this could not be satisfactorily done in any other way, the Survey rented a diamond drill from the Pennsylvania Diamond Drill Company, and placed the work under the supervision of Mr. W. L. Spoon in July of that year, and the work was continued until May, 1892. Two holes were bored in this field, the deeper one going down about 1,112 feet, and no valuable bed of coal having been penetrated, the work was abandoned. This negative result does not necessarily indicate the absence of valuable deposits of coal from the entire Dan River sandstone belt, but it does indicate their absence in the particular rocks penetrated by the borings. And while the result in this case is a negative one and led to no additional investments of capital, it prevented the expenditure of considerable sums of money which would have been lost in proposed mining operations.
>
> Near the southwestern end of this sandstone belt, between Walnut Cove and Germanton, the indications of the existence of workable beds of coal are more favorable than those in other portions of the region, and here they are worthy of further investigations, but in the immediate vicinity of Walnut Cove, where the borings were made, I think the negative evidence may be accepted as final.

No further development was done in the Dan River field until about 1907, when a citizen of Winston-Salem invested several thousand dollars in prospecting for coal at Walnut Cove. A diamond-drill hole about 300 feet deep and a slope driven on a thin bed of coal did not reveal any coal bed of value, and this attempt led to the present investigation of the field by the United States Geological Survey.

[1] Day, D. T., Mineral Resources U. S. for 1887, U. S. Geol. Survey, 1888, p. 280.
[2] Holmes, J. A., First Bien. Rept. North Carolina Geol. Survey, 1893, pp. 16-17.

OCCURRENCE OF COAL.

The Triassic beds in which coal occurs on Dan River extend northward over the State line into Virginia for about 8 miles, terminating in the vicinity of Bachelors Hall and Cascade. As the writer could learn of no occurrence of coal in this belt of sedimentary rocks north of Leaksville, plane-table mapping was not continued beyond that place, but a trip was made through the northern extremity of the area in order to find indications of the presence of coal.

NORTH OF LEAKSVILLE.

Black fissile shale was seen at a number of places, the northernmost prospect being a small roadside pit known as McGee's hole. This pit is one-fourth mile south of R. F. Soyar's house on the road from Cascade to Bachelors Hall and about 2½ miles west of the latter place. It is now caved, but is reported to have been driven about 15 feet. The strike is N. 70° E. and the dip 24° NW. The material on the dump is black shale and sandstone carrying fossil shells and coprolites, the same as are found in abundance at Walnut Cove. There is no sign of coal. The black shale band underlies beds of conglomerate carrying pebbles of quartz and mica schist. The next locality where coal has been reported is the Sharp plantation 2 miles from Draper, N. C., on the bank of Dan River. Chance makes the following statement[1] concerning this locality:

> At a place where coal had been reported on the Sharp plantation, we cleaned out an old pit and sunk it somewhat deeper upon an entirely valueless bed of slate, which measures:
>
> | | Ft. | in. |
> |---|---|---|
> | Slate, blue, carbonaceous | 1 | 6 |
> | (*a*) Coal and slate, variable | | 6 |
> | (*b*) Slick graphitic slate with coal streaks | 1 | |
> | (*c*) Slate, blue, carbonaceous. | | |
>
> Samples were analyzed from (*a*), (*b*), and (*c*) with the following results:
>
> (*a*)
>
> | | |
> |---|---|
> | Moisture | 1.65 |
> | Volatile matter | 4.82 |
> | Fixed carbon | 55.76 |
> | Sulphur | 4.76 |
> | Ash | 33.01 |
> | | 100.00 |
> | Weight of 1 cubic yard (pounds) | 3,199 |

[1] Chance, H. M., Report on an exploration of the coal fields of North Carolina made for the State Board of Agriculture, 1885, pp. 65-66.

(*b*)

Moisture	2.04
Volatile matter	6.03
Fixed carbon	15.25
Sulphur	1.47
Ash	75.21
	100.00
Weight of 1 cubic yard (pounds)	3,333

(*c*)

Moisture	2.49
Volatile matter	6.08
Fixed carbon	2.90
Sulphur	0.53
Ash	88.00
	100.00
Weight of 1 cubic yard (pounds)	4,310

The writer visited this plantation, which is now owned by Thomas Sharp, and was shown a small pit sunk many years ago about one-third of a mile west of the house at a spring near a tenant cabin. The dump shows black, sandy shale only. The same rock is found in the branch a few feet away, but with no trace of coal. Mr. Sharp says that about 2 miles west of the plantation house his father sunk a shaft 125 feet deep in the river bluff prospecting for coal, but found none.

LEAKSVILLE.

The easternmost exposure of black shale in the area included in the geologic map accompanying this report is in the east bank of Smith River, about 1,000 feet above its mouth. Here black shale and gray and black sandstone are well exposed, striking N. 76° E. and dipping 40° N. There is no sign of coal in this exposure. In the bank of Dan River at the east end of the covered bridge at the south end of Leaksville several black shale beds are uncovered in the road cut. The strike is nearly east-west and the dip varies from 45° to 60° N. A careful examination of the complete section containing a number of thin black fissile shale bands failed to disclose any coal. The nearest approach to coal is a bed of carbonaceous shale about 4 inches thick. It is reported that many years ago a tunnel was driven in the bank of the river at this locality on an 8-inch bed of coal, but the writer failed to find any trace of the tunnel—which may have been obliterated in highway construction—or any sign of coal whatever.

Red and yellow shales, yellowish sandstone, and sandy bands containing quartz grains the size of a pinhead are found on the south side of

Dan River at Leaksville. No conglomerate was seen in a distance of one-half mile south of or below the black shale. The rocks lying above the black shale and extending through Leaksville to the bridge over Smith River at Spray are red and yellow sandstone and shale. In the rapids above the bridge at Spray thick beds of hard brown to black sandstone and conglomerate are exposed, possibly the same which make the rapids in Mayo River between Mayodan and Avalon. The only report of coal in the village limits of Leaksville was by J. M. Price, who says coal was found in the bed of a small branch just below the railroad track and opposite the Baptist church. In company with Mr. Price the writer visited this locality and found 6 to 8 inches of black shale. As the limits of this black streak are plainly seen, it is evident that even if the shale were coal it is too thin to be of any value. Mr. Price also kindly conducted the writer to an old pit on his land about a mile up Dan River from Leaksville, where he had found, under black shale and resting on sandstone, a bed of black material 13 inches thick, supposed to be coal. Black shale outcrops in the fields and in the plantation road at this locality, but there is no sign of coal. The same beds are exposed in the bluff of the river above an old railroad grade from this locality to Leaksville and were examined at a number of places with negative results.

WADE PLANTATION.

Three miles west of Leaksville, on the old Wade plantation, now owned by Price & Stone and occupied by J. P. Wilson, there is as good coal as at any other place in the whole Dan River field. In the north bluff of the river and separated from it by an alluvial flat 300 yards wide are 40 or more old pits along the outcrop within a distance of less than one-half mile. Nearly all of them show the same black fissile shale that occurs through the entire length of the Triassic area, and at a few of them coal was found on the dump. It is said that during the Civil War a considerable quantity of coal was mined here by the Confederates and shipped down Dan River on flatboats. At the largest pit there is semianthracite coal on the dump and in the brush near the old loading platform. The writer made an excavation several feet deep at the mouth of an old inclined shaft and under a roof of sandstone and shale found beds as follows:

Section of coal bed on Wade plantation.

	Ft.	*in.*
Shale, hard, black, carbonaceous		6
Coal, semianthracite		6
Shale, carbonaceous, hard, platy		8
Sandstone, drab, clayey	2	0
Shale, black, carbonaceous at bottom.		

Mr. Wilson says his recollection is that at one of these pits a bed was exposed having an upper bench of coal 6 inches thick and a lower bench 12 inches thick separated by 12 inches of shale. The writer did not succeed, however, in finding more than the 6-inch bench. It may be that there are two benches of coal in a near-by pit. Coal was found only in the middle of the line of 40 pits. The beds dip about 35° N. Besides the slopes there were two or three vertical shafts, but both shafts and slopes are now caved so that the bed is completely concealed. The coal seems to be in one of the lower beds of black shale, for there are several bands of the same kind of shale in the hillside above these prospects. The age of these prospects is suggested by the fact that an oak tree 10 inches in diameter is growing in one of the pits. According to Major Morehead, of Spray, when mining operations stopped on the Wade plantation they were in a 32-inch bed of coal carrying 8 inches of shale in the middle. He says work was discontinued on account of trouble with water. The writer was thoroughly convinced by his examination of the prospects on the Wade plantation that the bed of semianthracite occurring here is too thin to work and extends along the strike only a few rods.

EAGLE FALLS.

In the north bank of Dan River, at Eagle Falls, a rapid in the river having a descent of only a few feet, there is black fissile paper-thin shale, but nowhere any sign of coal. The beds at the falls strike north-south to northwest and stand at various angles. A mile and a half north from Eagle Falls, along the course of a small branch, the beds strike from N. 15° E. to N. 48° E. and dip 18° to 25° NW. The black shale was not traced from point to point nor was the south side of Dan River visited except along the highway which crosses Suttle Bridge. The strike of the beds between Eagle Falls and the Wade plantation is almost at right angles to the common course through the Triassic area, due to folding of the strata. The course of Dan River at this place, as shown on the map, also indicates some peculiarity in the structure, with which the course of the stream may be closely related. Black shale beds are exposed in the road cut just west of Suttle Bridge, but there is no indication of coal here nor at an old prospect on the T. B. Lindsay plantation about 3 miles farther west. The position of the beds at Lindsay's, and also at the end of a plantation road 2 miles farther west, was determined by stadia measurement, as elsewhere throughout the field. The strike of the beds along this portion of the river varies from N. 70° E. to N. 80° E., and the dip, which is 32° N. near Suttle Bridge, varies from 35° to 65° N. in the vicinity of Madison.

MADISON.

At Madison gneiss is exposed in the river bank at the bridge over Dan River. The strike seems to vary from N. 15° W. to N. 60° W., and the dip is 12° to 30° NE. This strike is nearly at right angles to that of the sedimentary rocks which have a nearly east-west course at Madison. The lower member of the sedimentary series is a conglomerate containing pebbles of quartz, gneiss, and schist, and showing plainly its origin from the underlying crystalline rock. This conglomerate is exposed in the curve of the railway south of the depot. Above the conglomerate is a considerable thickness of red and yellow clay and sandy shale, with some buff sandstone. North from Madison for more than 4 miles red and purplish sandstone and shale with bands of yellow shale are seen. In the upper part of this section are beds of conglomerate from 1 to 2 feet thick, which contain subangular pebbles of quartz, schist and gneiss. The largest pebble seen is about 2 inches in diameter. About 4½ miles north of Madison outcrops of sedimentary rocks cease and characteristic soil, formed from the gneiss, is encountered. This makes the width of the Triassic belt at Madison about 5 miles.

It was reported to the writer that coal had been found at Madison, but on investigation the only prospect pit known in the locality proved to be entirely in black paper-thin shale such as is very common for many miles. This prospect is located on the Vaughan property, near Mr. Wilson's, at the southwest corner of the village. Black shale exposed in the road at Wilson's, a little less than a mile west of the depot, strikes N. 85° E. and dips 36° N. The shale bed passing close to Wilson's house probably is the uppermost of the carbonaceous zone. Black shale is well exposed also in the small branch in the yard of the Baptist Church and outcrops in a number of places in the main streets. As the supposedly coal-bearing beds pass directly through part of the village of Madison and are exposed in the street cuts, ditches, and cellars, it is reasonable to suppose that were there any coal here it would have been found long ago. There is, however, no indication of coal anywhere in the vicinity.

Southwest of Madison, between Dan River and the highway on the north, exposures are not good and the black shale was not recognized, although it is probably present. Diligent inquiry failed to disclose any prospect pits between Madison and the county line or any knowledge on the part of old residents of any coal in this vicinity. Near Reed Creek the strike changes from nearly east-west to about N. 30° E., and the dip ranges from 25° to 50° NW. The black shale zone is well ex-

posed on the bank of the Dan River at the county line in a cut made by the Norfolk and Western Railway, but although solid rock can be seen throughout much of the section, there is no coal in the exposure.

PINEHALL.

Gneiss is exposed on the south side of the river flat at Pinehall and conglomerate below the black shale is seen along the railroad between the depot and the brickyard. Black shale outcrops at the Methodist Church on the hill back of the settlement, and also in plowed fields on the Anderson plantation, and is of the same fissile character as that found throughout the field. No coal has been discovered here, however, except a few grains which might have come from seams a fraction of an inch thick, such as are sometimes found in carbonaceous shale. The beds here strike N. 55° E. and dip 40° NW. West from Pinehall the next exposure of black shale is in a small branch north of the brickyard. A small pit has been dug here on one of the black shale bands. The outcrop uncovered in the bank of the branch showed a few inches of black shale containing some specks of coal. The whole band of black shale is not over 2 feet thick.

The report that many years ago a blacksmith dug coal on the Will Hairston plantation for use in his forge led to the discovery of an old pit in the woods beside the road, about half a mile southwest of the Hairston house. It is a shallow opening probably never over 6 feet deep, but the writer found 3 or 4 feet of black shale with about 6 inches of good coal at the top of the bed under a clay shale-roof. The strike is N. 80° E. and the dip 30° NW. This in all probability is a very small lens. Thirteen distinct beds of black shale are exposed in the road on the J. E. Willis plantation just above the mouth of Town Fork and 250 yards west of the stream. The strike is N. 48° E. and the dip 42° NW. These shales carry abundant fossil fish scales and are fairly well exposed, but no trace of coal could be found in any of the beds.

WALNUT COVE.

Within a radius of 3 miles from Walnut Cove are 50 or 60 excavations ranging in size from small test pits to incline shafts 100 to 150 feet deep. The largest openings are driven down the slope of a black shale and coal bed dipping at an agle of 35°.

Semianthracite coal has been found here, but in no place is it more than a few inches thick. A bed of what appears to be coal, ranging in thickness up to 10 feet, has been one cause of so much prospecting. This material is bright, black, soft, and flaky and has the appearance of coal,

but on testing it is found that it will not burn and that it carries from 40 to 64 per cent ash. It is so soft that even at a depth of several feet below the surface it can be dug with a shovel. This material, which has been the source of the report concerning the presence of coal in quantity in the vicinity of Walnut Cove, is really a carbonaceous shale which has been subjected to so much squeezing and movement that innumerable slickensides have been produced in it, thus giving the shiny appearance to all particles. As only a small amount of carbonaceous material is sufficient under these conditions to give a glossy appearance, it is not surprising that this carbonaceous shale has excited considerable interest. Certain persons in Walnut Cove claim to have burned it, but the fact that it is not mined or used, although the main prospects are very close to the village, indicates its poor quality. The tests made by the writer (see p. 144), are conclusive that this material can hardly be classed as a fuel.

Some of the more remote pits on the east, such as that at J. H. Brown's place and the pits on Bull Run, show black shale on the dump, but no sign of coal. In the immediate vicinity of Walnut Cove, however, some small amounts of coal have been found. Beginning with a pit east of the village near a tenant's cabin on Cabel Hairston's land, the description will proceed west to Oldfield Creek. Reference to the accompanying figure showing in detail the position of the prospects in

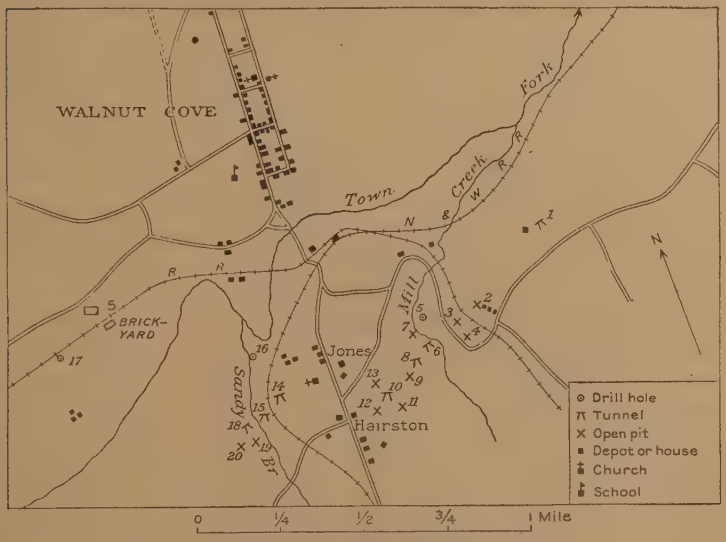


FIG. 6. Map showing location of prospects near Walnut Cove, N. C.

the vicinity of Walnut Cove will aid in understanding the relations of the exposures under discussion. Numbers on the map refer to the numbers at the beginning of the following paragraphs:

1. A tunnel about 50 feet long on Cabel Hairston's land 50 yards from a tenant cabin about 2,000 feet east of the Southern Railway bridge over Mill Creek. Here is exposed a bed of soft carbonaceous shale 4 to 5 feet thick between roof and floor of yellow to black clay shale carrying coprolites. The bed seems to be composed entirely of a glossy black shale, but chips of good coal on the dump suggest the possibility of a few inches of true coal in the bed. If the bed does contain coal it is in such small quantity as not to be of value.

2. An old pit just east of the Southern Railway track and 800 feet south of the Mill Creek bridge shows only fissile black shale on the dump. Bedrock is not exposed here.

3. On the opposite side of the track from No. 2 is an old pit now caved and full of water, which shows pieces of coal on the dump. This pit is said to have been dug by H. B. Robson. The strike is N. 70° E. and the dip 40° NW.

4. A few rods south of No. 3 and just below the Southern Railway track is another excavation made by Robson on a band of black, slightly micaceous sandstone not over 20 inches thick. The surface exposure is black dirt and shale and the upper 5 inches of the bed contains streaks of good coal.

5. A diamond-drill hole on the east bank of Mill Creek about 300 yards above the Southern Railway bridge is reported to be about 300 feet deep, but no coal was found. It was sunk at the expense of W. T. Brown and others, of Winston-Salem, N. C.

6. On the west side of Mill Creek at this same locality is a dump at the mouth of a tunnel which is caved, but is said to have been 110 feet long. No good coal was found.

7. A few rods north of the tunnel along the hillside a shallow trench has been cut for about 200 feet across the strike of the beds. It reveals several bands of black shale, but no coal.

8. An incline shaft has been sunk near the bank of Mill Creek and 1,000 feet south of Dr. Jones's house in Cabel Hairston's field. This will be called Brown's shaft because it was sunk at the expense of W. T. Brown and others, of Winston-Salem, who also sunk the diamond-drill hole mentioned above. This shaft is said to be about 150 feet deep and to incline 47° at the dip of the beds at this point. It is cut nearly 9 feet wide and the soft shale roof is supported by heavy stulls and lagging. Hoisting was done by steam engine and rope cable, with a broad-gauge

car running on timber rails. Water now fills the shaft within 10 feet of the surface. The section exposed at the mouth is as follows:

Section in Brown's shaft.

	Ft.	in.
Shale, drab, roof.		
Coal, bright, somewhat crushed		8
Shale, sandy, carbonaceous crushed, soft, flaky	1	9
Shale, yellow, floor.		

The upper part of the lower bench is the soft carbonaceous material which has been mentioned above as resembling coal, and the lower part of the bench next to the floor is black and sandy and also appears to have been crushed and slightly crumpled. Cabel Hairston says that in driving this shaft a horseback or roll in the floor was encountered which cuts out practically all of the bed, but that in driving through this roll nearly the whole thickness of the bed was found on the other side. A sample of the best coal on the dump, selected from a considerable number of pieces, was analyzed and shows a fairly good quality of fuel, but as the actual coal has a thickness of only 8 inches it is readily seen that this bed is of no commercial value. The analysis (No. 10391) is given on page 146.

About 20 feet above this shaft is a shallow pit which shows a few inches of flaky crushed carbonaceous shale on one side and none on the other side of the excavation.

9. Sixty feet west of Brown's shaft is a surface cut which shows two beds of black shale. The upper bed carries from 2 to 3 inches of bright coal. The shale is slightly micaceous and contains abundant coprolites.

10. In this same field and about 250 yards east of Cabel Hairston's house and the same distance from Dr. Jones's an incline shaft is reported to have been sunk by a Mr. Evans. It has long been abandoned and is now full of water. At the mouth of this shaft is exposed a carbonaceous bed, 3 feet 11 inches thick, of which the bottom bench is 11 inches of black shale. The remainder of the bed, 32 inches thick, is composed of slaty, slightly micaceous, carbonaceous shale with streaks of bright coal and with 8 or 9 inches of coal at the top. It is all badly crushed and the lumps have bright slick faces. A roll in the shale roof nearly cuts out the thin top coal at about 6 feet below the surface, but it comes in again 3 feet below at a different angle and with good appearance. W. A. Gladwell, of Walnut Cove, who worked in this shaft, reports that it is 128 feet deep and that the section as exposed at the surface continues for about 20 feet, where it increases to about 4 feet 4 inches and then decreases to about 5 inches on account of a roll in the floor. He says that the coal, which at the surface is soft and flaky, gets harder with

depth and carries a sulphur band. He reports that the whole bed is completely cut out at the bottom of the shaft. The dip is 37° to 48°.

The Evans shaft is about 8 feet wide and 6 feet high. It contains one set of stulls and lagging at the mouth. Roof and floor are shale. The bed appears to be the same as that exposed at Brown's shaft.

11. Fifty feet below the Evans shaft a small pit was reopened by the writer and shows the following section:

Section at small pit below Evans shaft.

	Inches.
Roof, shale, drab.	
Coal, weathered, slightly micaceous	8
Shale, drab to black, micaceous, sandy	2-6
Coal, probably good, under cover	7
Floor, shale, black, micaceous, lumpy.	

12. Fifty feet west of the Evans shaft is a pit opened by Cabel Hairston, probably on the same bed. It has a very irregular clay roof and shows about 3 feet of carbonaceous shale with a mere streak of crushed coal at the top. The excavation was driven about 15 feet and slightly down the dip until water stopped the work. At the back end of the pit the band of crushed coal at the top is nearly 6 inches thick. It is evidently very irregular, and although of good quality, is so small in amount as not to warrant further prospecting.

13. About 500 feet south of Dr. Jones's house, and the same distance from Cabel Hairston's, in the latter's field, the writer reopened an old pit on a higher bed than that on which the Evans shaft was sunk. Particles of apparently good coal on the dump were the cause for the excavation of this pit, which, to judge from the size of the dump, may have been 5 or 6 feet deep. Under the sandy shale roof is a bed of carbonaceous shale of a soft, flaky character, easily excavated, and of such bright appearance as to closely resemble coal. A shaft was sunk 11 feet deep and the bed found to be 10 feet 2 inches thick, practically all of bright carbonaceous shale. In spite of the promising appearance of this material, several attempts to burn it, both in stoves and blacksmith's forges, have failed, and analyses made both by the Bureau of Mines and by the chemical laboratory of the Geological Survey show that it contains from 40 to 65 per cent ash. Although this bed has considerable thickness and may possibly continue for some little distance, its quality is such that it is of no value as a fuel.

14. On the east side of the Norfolk and Western Railway track in the rear of the church and one-half mile southwest from the railway station at Walnut Cove there is a slope about 8 feet wide and 6 feet high, now full of water and of unknown depth. The writer had an excavation made in the side of the slope and found the following section:

Section in slope near Norfolk and Western Railway track.

	Inches.
Roof, shale, drab.	
Coal, bright, flaky	8
Shale, soft, carbonaceous	9
Clay, with coal streaks	12
Shale, soft, carbonaceous	12
Floor, shale, black, sandy.	

15. On the opposite side of the railroad track and in the bank of Sandy Branch at this same locality a tunnel has been driven on the same bed and probably connecting with the slope described as No. 14. It shows a carbonaceous bed about 4 feet thick, composed mainly of carbonaceous sandstone and soft crushed flaky black coal with thin lenses of bright semianthracite coal under the shale roof. The roof is irregular and a thin band of coal exposed for about 8 feet pinches out at one end and is cut off abruptly at the other end, where it is about 5 inches thick. The strike here is N. 40° E. and the dip 34° NW. This opening is also said to be the work of Mr. Evans.

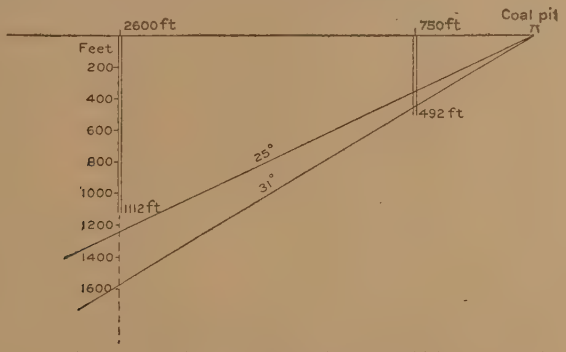


FIG. 7. Diagram showing relation of diamond-drill holes at Walnut Cove, N. C., to principal coal beds.

16. A diamond-drill hole was sunk by the North Carolina Geological Survey to a depth said to be 492 feet in the east bank of Sandy Branch, about 750 feet below opening No. 15 and 2 rods from a mineral spring, in an endeavor to find the character of the coals at considerable depth. The report by J. A. Holmes,[1] who was State Geologist at that time, claims only negative results. A resident of Walnut Cove said that the hole on Sandy Branch passed through beds of coal, but the diamond drill was rotating so fast that only ground-up material was found in the core. This seems to be evidence that the carbonaceous beds which the drill passed through are soft, flaky material, the same as that found at

[1]First Bien. Rep. North Carolina Geol. Survey, 1893, pp. 16-17.

the surface (Fig. 7), and is fair proof that the soft, carbonaceous shale does not become hard coal under heavy cover.

17. Another diamond-drill hole was sunk by the North Carolina Geological Survey about a mile west of Walnut Cove and on the south side of the Southern Railway track west of the brickyard. It was bored to a depth of about 1,112 feet without penetrating any valuable bed of coal. Some persons at Walnut Cove think that this drill hole is not deep enough to reach the coal beds, an idea which may be correct. The accompanying diagram (Fig. 7) shows the relation of these two drill holes to the coal bed on Sandy Branch 750 feet from the lesser hole. The distance from coal pit No. 15 to the deep drill hole near the brickyard is 3,100 feet, but to a point along the strike through the drill hole and normal to the strike from the coal pit is 2,600 feet. This pit is 15 feet higher than the mouth of the shallow hole and at about the same level as the deep hole. In the Norfolk and Western Railway cut at the coal pit the dip is 31° and on the northwest side of the basin about 20°. A dip of 31° carries the coal bed to a depth of 1,560 feet at the position of the deep drill hole by the brickyard, and a dip of 25° would carry it to a depth of about 1,200 feet. The dip of the beds under the valley of Town Fork at this point probably is not less than 25°, in which event the deeper drill hole certainly would not be deep enough to reach the principal coal and carbonaceous shale bed.

18. In an open field about one-fourth mile north of the highway and on the west side of Sandy Branch is a large drift, possibly 100 feet long, which was driven many years ago and now is inaccessible, being full of water and partly caved. The mouth of this drift was reopened and disclosed the following section:

Section at drift west of Sandy Branch.

	Ft.	in.
Roof, shale, drab:		
Shale, black, sandy		5
Shale, soft, flaky, carbonaceous	1	3
Dirt, black		1
Shale, soft, flaky, carbonaceous		8
	2	5

The floor was not seen, but is presumed to be shale, and the impression was obtained that this bed is the one known as the soft-coal bed which has been opened at a number of places farther east.

19. At a pit 100 feet farther west, which was opened by the writer, there is 30 inches of drab and black clay shale with lenses of slaty coal. The greatest thickness of coal seen is about 3 inches.

20. In the same field and just above the pit last mentioned was an incline shaft which is now completely filled. An excavation made at the entry showed 4 feet of soft, black, flaky, carbonaceous shale. The floor was not reached. Several small pits have been sunk on other beds of black shale in the same field.

There are several small prospects a little over a mile southwest of Walnut Cove on the Hensdale land, in a ravine west of the plantation houses and about 200 to 300 yards from Town Fork. These pits are on different beds of black shale and show the same soft material as is found elsewhere, but reveal no true coal.

DAVIS PLANTATION.

About one-fourth mile east of Ed Davis's house, which is on the road from Walnut Cove to Germanton and just east of Oldfield Creek, are three openings near the edge of the timber. One of these is a small pit on one of the lower black shale beds, but as it is now caved full, the thickness of the bed was not learned. A hundred yards from it is a slope which was driven on a bed of black carbonaceous sandstone with about a foot of crushed carbonaceous shale at the top, underlying a very irregular roof. From the little that can be seen at the mouth of the slope, which is now caved full, it is judged that the carbonaceous shale is very pockety. This is the only place in the entire Dan River field, so far as the writer discovered, where iron rails were used for track. The indications are that the original operator intended to develop a mine here, but gave it up when the shaft had been driven to no great depth. The strike is N. 60° E. and the dip 40° NW.

North or back of Davis's house there are six pits and slopes which were sunk many years ago on a bed of soft carbonaceous shale, but which have long been abandoned. The largest of these, the middle one, is a slope driven 30 or 40 feet down the dip with one small room turned to the right. A lens of soft carbonaceous shale 13 inches thick is exposed at the upper end, but about 18 feet down the dip it pinches out completely. It is no harder at the lower end, where under several yards of cover, than it is at the mouth. This slope evidently was driven with the hope that the black shale would become coal and increase in thickness under greater cover. The westernmost of the six openings, almost directly behind Davis's house, is a slope driven down the dip on a 2-foot bed of carbonaceous shale. It was probably found, after considerable energy had been expended, that this shale would not burn, nor did it turn to coal at greater depth, and operations were abandoned.

OLDFIELD CREEK.

Near an old dam site in the bank of Oldfield Creek, about halfway between the highway and Town Fork, where the black shale zone crosses the stream, several openings were made many years ago. They are now completely filled and only slight traces of them can be found. Black shale, but no coal, was discovered on the dumps. A few rods west of the creek bank and at the end of a road which runs nearly parallel with the west bank of the creek there are four old pits. Numbers heading the following paragraphs correspond with those on Fig. 6.

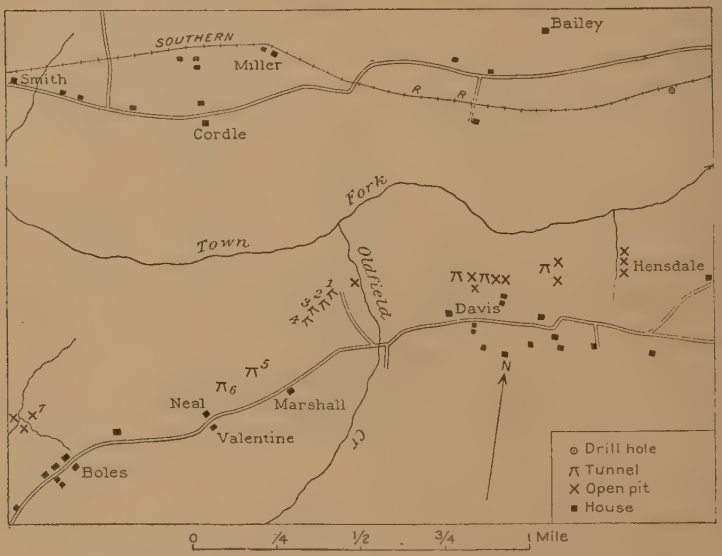


FIG. 8. Map showing location of prospects near Oldfield Creek, N. C.

1. The northernmost pit is driven S. 65° W. on a bed which dips 22° NW. It is full of water and its length could not be determined. The roof is buff sandy shale, under which is about 42 inches of carbonaceous material. At the top of the bed is 7 or 8 inches of semi-anthracite and the remainder is anthracite, but high in ash. It has a bright, coaly appearance, but is so badly crushed that it crumbles to small flakes. The floor is micaceous carbonaceous sandstone. It is said that coal taken from this pit was screened and burned at Walnut Cove.

2. About 75 feet south of the pit above described an open cut has been run into the coal bed and turned in both directions. This was reopened

by the writer, and in the drift on the left there was found 9 inches of bright, fairly hard coal under a sandy shale roof and underlain by 28 inches of bright coal having the same soft, flaky character as the carbonaceous shale at Walnut Cove, but of brighter, less ashy appearance. Analyses given on page 146 show that the upper 9 inches of coal is semianthracite and that the lower bench carries over 20 per cent ash, which, together with its crushed, flaky condition, makes it a poor fuel.

3. The third pit, distant about 25 feet, is completely caved. There is coal on the dump, but the pit was not reopened.

4. The fourth pit also was completely caved, but the writer had it reopened, and found under a yellow, sandy shale roof a coaly bed 37 inches thick. The roof is irregular, with slick rolling faces, which appear also in the coal itself, suggesting considerable movement. The upper 8 inches of the bed is bright coal crushed so that pronounced prismatic cleavage is developed. The middle part of the bed is soft, bright coal, crushed to a soft, flaky condition, and the lower part is both slaty and bright coal like the top bench. The bed dips very irregularly at angles ranging from 25° to 45° NW. These four openings are on the same bed and show that, although there is semianthracite here, the hard, clear coal is nowhere more than a few inches thick and is underlain by 2 to 3 feet of crushed ashy coal of promising appearance, but of little value. These are the best showings of coal in the whole Dan River field.

5. On the Morris plantation, formerly Poindexter, opposite J. V. Marshall's house, is a slope now completely caved, which is said to have been nearly 150 feet long. A few pieces of coal were found on the dump, and it is believed that this is on the same bed as that which has been prospected so extensively in the bank of Oldfield Creek.

6. Three hundred yards west of Marshall's house, on the Morris plantation, is a drift driven S. 65° W. about 80 feet, with a bend to the left. At the face of this drift there is a coaly bed 42 inches thick, a little of which is hard and bright coal, but most of it soft, flaky carbonaceous shale. Throughout the length of the drift the bed is soft and breaks in lenses suggesting severe crushing. It seems no harder at the face of the drift than at the surface. This prospect affords one of the best opportunities for examining the bed under cover, and the writer had the drift reopened and cleaned out in order to obtain an idea of the character of the coaly material.

On the H. T. Boles plantation, 3 miles west of Walnut Cove, several small pits have been sunk in the wood lot northwest of the house. Black

carbonaceous shale of bright promising appearance is exposed and a little coal may be found, but as the true coal nowhere has a thickness of more than 2 inches none of the prospects show anything of value. At one of the prospect pits (No. 7 on Fig. 6, p. 135) in the bank of a branch in front of Boles's house, where the strike of the beds is N. 40° E. and the dip 23° NW., after reopening the pit the following section was measured:

Section in pit on Boles plantation.

	Inches.
Roof, sandstone, shaly.	
Shale, paper-thin, carbonaceous	5
Dirt, black	10
Shale, soft, flaky, carbonaceous	12-15
Floor, sandstone, carbonaceous, and shale, drab.	

It is reported that several small pits have been reopened between the Boles plantation and Germanton on the same black shale beds, but the writer failed to discover more than one or two in the brush and timber. These were only shallow pits, dug so many years ago that it is impossible to tell anything about them without considerable excavation. Only fragments of black shale could be found on the dumps, and it is presumed that there is no coal.

GERMANTON.

It is reported that coal has been found at Germanton, and a section is quoted by Woodworth[1] showing two beds of coal, each 18 inches thick, separated by 1 foot of "slate." Inquiry failed to locate these beds and led only to a report of coal being found in the wheel pit of Slate's mill. Although the mill was visited when repairs were being made and the water was out, the wooden case in which the water wheel stands concealed the bedrock. Conglomerate and sandstone are exposed between the mill and the highway on the south. The black-shale zone probably lies under the alluvium of Town Fork at this point and certainly must terminate close to Germanton, for gneiss is found on the southwest, west, and north sides of the village and is exposed in the village streets.

PRACTICAL TESTS.

The bright black carbonaceous shale exposed in a number of prospects at Walnut Cove is believed by some of the residents of that village to have fuel value, although none of them use it. To test its character the writer endeavored to burn in an open hearth some of the freshly

[1] Woodworth, J. B., The Atlantic Coast Triassic coal field (in North Carolina): Twenty-second Ann. Rep. U. S. Geol. Survey, pt. 3, 1902, pp. 50, 51.

mined material from the 11-foot shaft near Cabel Hairston's house. Although the brightest, blackest lumps were kept red-hot on a wood fire for several hours, they could not be made to burn. A similar attempt was made in a sheet-iron box stove with a good draft produced by a hot wood fire, and chunks of this glossy black shale were kept red-hot for three hours, at the end of which time the chunks were taken out and found to be of the same size as when put on the fire and changed only in part to a reddish color. Lumps of the brightest black shale placed in a crucible and kept at white heat in a furnace fire for an hour gave off flame for the first few moments after becoming heated, but after that seemed dead and did not diminish in bulk. When removed from the fire they were of the same size and shape, but had changed from black to gray and red. The same experiment in the laboratory over an air blast gave the same result. The platinum crucible quickly brought to white heat ignited the shale so that it gave off a flame for a moment, but seemingly after the carbon on the slick faces had burned off there was no more combustion. When anthracite of the same bulk would have been consumed, the shale remained intact without loss of bulk.

A blacksmith at Walnut Cove, Mr. Clodfelter, claimed to have burned this coal in his forge and did so to his own satisfaction at the request of the writer. A fire was started on the forge with shavings and the carbonaceous shale applied. By mixing with the fire some of the ashes or coke from a former fire Mr. Clodfelter soon heated a small bar of iron to white heat. In order to have impartial tests, some of this carbonaceous shale was taken to Madison and tested at two separate blacksmith shops by men who were not familiar with it. In each test the forge was cleaned completely and a fresh wood fire made. The substance was brought to a red heat and kept so for some time by blowing with the bellows, but the conclusion of both blacksmiths was that it was not coal; it was only rock. The writer, therefore, is convinced that Mr. Clodfelter was able to heat iron by the coke mixed in with wood rather than by the carbonaceous shale. Even if this shale would burn, the fact that it crumbles to small flakes is enough to condemn it as a shipping fuel.

ANALYSES.

In the following table are given five analyses made by the United States Geological Survey.

All the samples from which these analyses were made were collected by the writer, as described.

Analyses of Coal Samples from the Dan River Coal Fields, North Carolina.

(A. C. Fieldner, Chemist in charge.)

Laboratory Number.	Location.	Thickness.		Air-drying Loss.	Form of Analysis.	Proximate.					Heat Value.	
		Coal Bed.	Part Sampled.			Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Calories.	British Thermal Units.
		Ft. in.										
10393	Oldfield Creek	3 1	9 inches at top.	3.1	A	4.0	9.6	80.8	5.6	2.70	7,790	14,020
					B	.9	9.9	83.4	5.8	2.79	8,040	14,470
					C	------	10.0	84.1	5.9	2.81	8,115	14,600
					D	------	10.6	89.4	------	2.98	8,620	15,510
10391	Walnut Cove	8	Best coal from dump.	1.9	A	3.0	9.1	65.8	22.1	.82	6,235	11,220
					B	1.1	9.3	67.1	22.5	.84	6,355	11,440
					C	------	9.4	67.8	22.8	.85	6,430	11,570
					D	------	12.1	87.9	------	1.10	8,330	14,990
10395	do	10 2	Best coal from dump.	1.9	A	------	------	------	39.4	------	------	------
					B	------	------	------	40.1	------	------	------
10392	do	4 0	4 feet	2.1	A	------	------	------	22.1	------	------	------
					B	------	------	------	22.6	------	------	------
10394	Oldfield Creek	3 1	2 feet 4 inches of lower part.	7.2	A	------	------	------	20.5	------	------	------
					B	------	------	------	22.1	------	------	------

Laboratory No. 10393.—Taken from pit on Oldfield Creek reopened and marked No. 2 on figure 6. Sample represents a top bench 9 inches thick which overlies 28 inches of crushed, flaky coal.

Laboratory No. 10391.—Sample represents 8 inches of coal at top of bed exposed in Brown's slope at Walnut Cove, marked No. 8 on figure 4. Sample made by selecting best pieces on the dump, exposed to weather two years.

Laboratory No. 10395.—From a shaft 11 feet deep sunk by the writer at Walnut Cove and marked No. 13 on figure 4. This shaft exposed 10 feet 2 inches of carbonaceous shale and the sample was taken by selecting the best-looking material on the dump.

Laboratory No. 10392.—From a tunnel at Walnut Cove on Sandy Branch, near the Norfolk and Western Railway track, marked No. 15 on figure 4. The sample represents the entire thickness of a crushed, flaky coal.

Laboratory No. 10394.—Taken from pit on Oldfield Creek reopened and marked No. 2 on figure 6. Sample represents 28 inches of crushed, flaky coal which underlies a 9-inch coal bed.

In the table the analyses are given in four forms, marked A, B, C, and D. Analysis A represents the composition of the sample as it comes from the mine. This form is not well suited for comparative purposes, for the amount of moisture in the sample as it comes from the mine is largely a matter of accident, and consequently analyses of the same coal expressed in this form may vary widely. Analysis B is of the sample after it has been dried at a temperature a little above the normal

until its weight becomes constant. This form of analysis is best adapted to general purposes of comparison. Analysis C represents the theoretical condition of the coal after all the moisture has been eliminated. Analysis D represents the coal after all moisture and ash have been theoretically removed. This is supposed to represent the true coal substance, free from the most important impurities. Forms C and D are obtained from the others by recalculations. They should not be used in comparison, for they represent theoretical conditions that never exist.

Analyses 10393 and 10391 give fuel ratios of 8.4 and 7.3, respectively, which shows that the coal is a semianthracite. Analysis 10395 is of the bright flaky carbonaceous shale which has been the principal cause for the extensive prospecting near Walnut Cove. The high percentage of ash from a sample of the best parts of the 10-foot bed removes this shale from any present consideration as a fuel. Another analysis of the average run of this shale from the same shaft, made by George Steiger in the chemical laboratory of the United States Geological Survey, gave 64.68 per cent ash. Analyses 10392 and 10394 are of coal which is so thoroughly crushed that it is very much like the carbonaceous shale in appearance. Its crumbled condition and high percentage of ash spoil it for fuel.

The following analyses, quoted from Chance[1] give some information about the quality of the thin bed of true coal. Chance says that the average section of the bed on the Wade place near Leaksville is an upper bench of coal a foot thick separated from a lower bench of coal 1 foot 1¾ inches thick by 7 inches of slate, and gives the following tables:

The analysis of the upper bench shows:	
Moisture	11.67
Volatile matter	30.19
Fixed carbon	48.00
Sulphur	0.49
Ash	9.65
	100.00

The high percentage of moisture is evidently accidental.

The lower bench shows, on analysis:	
Moisture	5.35
Volatile matter	9.49
Fixed carbon	64.31
Sulphur	0.58
Ash	20.27
	100.00

[1]Chance, H. M., Report on an exploration of the coal fields of North Carolina made for the State Board of Agriculture, 1885, pp. 62-66.

An average sample from both benches gave, on analysis:

Moisture	3.92
Volatile matter	5.47
Fixed carbon	73.95
Sulphur	2.44
Ash	14.22
	100.00

A sample picked from the best coal that could be found here gave, on analysis:

Moisture	3.70
Volatile matter	4.67
Fixed carbon	81.58
Sulphur	2.23
Ash	7.82
	100.00

These analyses are of coal which occurs in a bed too thin to be mined with profit and which has a lateral extent of only a few hundred feet, if indeed it is more than a few rods.

Woodworth[1] gives the following analyses of coal at Walnut Cove:

Analyses of coal from Dan River area.

	1	2	3
Fixed carbon	75.96	76.56	55.47
Volatile matter	11.44	13.56	17.99
Ash	12.00	12.00	26.16
Sulphur			5.56
Water			.38

1 and 2. Analyses by Dr. Genth, about 1871, from coal near Stokesburg.
3. Coal from Walnut Cove, Stokes County. Analysis by J. E. Whitfield, in Bull. U. S. Geol. Survey, No. 42, 1887, p. 146.

Undoubtedly analyses 1 and 2 represent coal from the 8-inch bed which lies on top of the carbonaceous shale in some pits at Walnut Cove. It is very evident that No. 3 is too high in ash and sulphur to be classed as a desirable fuel.

CONCLUSION.

After a thorough and careful examination of the Triassic beds in the Dan River field the conclusion is reached that there is no reason to expect to find commercially valuable coal beds in this district. The beds of semianthracite found near Walnut Cove and near Leaksville

[1]The Atlantic Coast Triassic coal field (in North Carolina): Twenty-second Ann. Rep. U. S. Geol. Survey, pt. 3, 1902, p. 51.

are only a few inches thick and of small lateral extent. Being both thin and discontinuous, they are wholly unimportant. It is therefore useless to expend money and energy in this region in the hope of developing a coal mine.

GRAPHITE.

During the past two years there has been considerable interest taken in the occurrence of graphite in North Carolina, and more or less prospecting has been done for this mineral in Cleveland, Catawba, and Macon counties. The graphite deposits near Graphiteville, McDowell County, have also received some attention. Some demand has arisen in the past two years for a low-grade graphite, which has resulted in the production of a large quantity of this mineral from Bartow County, Georgia. The material is ground and used as a filler and absorbent in the manufacture of fertilizers. The material mined is a graphitic schist or slate, the graphite content varying very widely. Such graphitic schists are found in many localities of the Piedmont section of North Carolina, notably in McDowell, Cleveland, and Catawba counties. Some of this material has been observed and found to contain a very high percentage of graphite; in others, the material gets down as low as 2 to 15 per cent of carbon. It also occurs associated with pegmatite in Alexander County, about 5 miles from Taylorsville.

In 1911 there were a few tons of graphite produced by Mr. Charles Rennie of Franklin, N. C., from a deposit located near Aquone. The material was shipped to the Federal Graphite Company at Warren, Ohio. In 1912 there were a few tons of graphitic schist mined at Barrett's Mountain, Alexander County; but none was sold or shipped.

On account of the many inquiries that have been received at this office for information regarding graphite, and as our early publications regarding this mineral are practically out of print, there is given below the report by Mr. Edson S. Bastin of the U. S. Geological Survey, on "Graphite," which was published in "Mineral Resources of the United States" in 1912.

GRAPHITE.

By Edson S. Bastin.

"The production of natural graphite in the United States is sporadic, because the milling of disseminated flake graphite is still in the experimental stage and the product is of uneven grade. Because of this unreliability of the domestic supply, most of the large consumers prefer to depend on imported material.

"The cause of the unsatisfactory condition of the domestic industry is to be found in (1) the superiority of much of the Ceylon graphite to any graphite that is mined in this country; (2) the low cost of labor in Ceylon, which permits cheap mining, careful sorting, rubbing up, and blending of the product; (3) the facts that the largest domestic deposits are schists which carry small flakes of graphite disseminated through them and that the separation of the graphite from the accompanying minerals, especially mica, in such rocks is a problem of unusual difficulty. The one firm which can be said to have become firmly established in the treatment of such graphite rocks, the Joseph Dixon Crucible Company, possesses important advantage over other firms in that it manufactures much of its product into graphite paints, graphite grease, etc., before placing it on the market. When the margin of profit is small, such control of markets becomes of vital importance.

"Today there are more abandoned graphite mines and mills in the United States than there are in operation. The number of times that some of these properties have changed hands in the course of a few years evinces a record of misrepresentation and disappointment that can hardly be equaled in any other branch of mining, and many properties have been notoriously associated with stock manipulations of doubtful character. It should be clearly understood by any one who contemplates the development of one of the flake-graphite deposits that the technology of concentrating such materials is yet in its infancy; that there are no well-established systems of treating the materials, such as exist, for example, for the treatment of gold or copper ores; and that the product obtained is variable in quality and in market value and subject to severe competition with foreign graphite. The largest part of the foreign graphite that comes into this country is brought in by American firms who either control or own the foreign mines or have purchasing agents abroad, and are, therefore, in a position to take immediate advantage of any change in the markets at home or abroad. In general, the cost of producing flake graphite is so high and the price at which it is sold so low that even under the most economic conditions the margin of profit is small. Moreover, certain rocks that carry graphite contain other minerals which preclude any possibility of successful concentration—such, for example, are rocks in which graphite flakes are interleaved with mica—and a careful study of the material by an expert should precede any attempt at development.

"In a later paragraph the uses of graphite are discussed. These uses are manifold, but it should be remembered that graphite from any

one property will be adapted for only certain of these uses, and that not only the purity of the graphite, but its physical properties, are of importance in determining the purposes for which it is suited. Crucible manufacture, for example, demands a flaky or fibrous graphite high in carbon, and Ceylon lump, which retains its flaky character after grinding, is excellently adapted to this use. For foundry facings, on the other hand, an earthy, impure graphite is usually adequate. For many purposes the best result can be obtained only by a careful blending of graphite of several different kinds. This is the case in the manufacture of pencils.

"The blending in various proportions of slightly different grades of graphite from different mines to obtain products which meet the varied requirements of purchasers is one of the steps in preparing the Ceylon graphite for the market. To a certain extent blending is practiced by some American dealers, especially in marketing the amorphous forms.

PHYSICAL AND CHEMICAL PROPERTIES.

"Chemically, the purest graphite is carbon with a fraction of 1 per cent of ash and volatile matter. In the trade graphite is frequently referred to as plumbago, or black lead. The graphites of commerce contain various impurities, sometimes in large quantities. Graphites showing 80 to 95 per cent graphitic carbon are pure enough for the requirements of the general trade; and for many uses, such as paint making, graphites with as low as 30 to 35 per cent of graphitic carbon are employed. The mineral possesses certain physical characteristics which usually enable it to be easily recognized. These are its steel-gray to blue-black color, extreme softness (1 to 2 in the scale of hardness), greasy feel, and the property of making a black metallic mark on paper. It is opaque in even the thinnest flakes, and the flakes, though flexible, are not elastic. Its temperature of fusion or volatilization is unknown, but is probably above 3,000° C. It is combustible at temperatures between 650° and 700° C. The specific gravity generally lies between 2.20 and 2.27. The only mineral with which graphite might be confused is molybdenite, from which it differs slightly in color, the molybdenite having a somewhat bluish or greenish tinge. The two minerals may be distinguished by simple blowpipe tests. Graphite is in general a better conductor of electricity than are most of the amorphous forms of carbon. Tests by P. M. Lincoln, of the Niagara Falls Power Company, showed a specific resistance of 0.00032 ohm in an artificial graphite electrode, while an amorphous carbon electrode of the same size showed a resistance of 0.00124 ohm.

"In the trade two principal varieties of graphite are generally recognized. The graphite that possesses a lamellar, scaly, flaky, or fibrous structure is classed as crystalline. The other forms of graphite, of whatever occurrence or appearance, are classed as amorphous. The two varieties are not sharply differentiated, and the distinction appears to be largely in the size of the graphite particles. Much of the so-called amorphous graphite mined in the United States is shale or slate, containing varying percentages of carbonaceous material. In such cases it is often impossible even with chemical tests to tell whether the carbon is graphite or amorphous carbon.

"From the commercial standpoint the physical character of graphite is usually of the utmost importance, as will be further discussed in the section on uses.

ORIGIN.

"Graphite is known to occur in nature in each of the three great groups of rocks: igneous, sedimentary, and metamorphic. It also occurs as veins which may traverse rocks belonging to one or all of these groups.

"Graphite has been observed in numerous places in igneous rocks so intercrystallized with the other rock minerals as to leave no doubt that it formed a part of the molten magma from which the rock crystallized. In some such occurrences, where the igneous rock is associated with carbonaceous sediments, it is probable that the magma absorbed carbon from these sediments, but in others it is equally probable that the graphite is of inorganic origin, or at least came up from great depth as an integral part of the igneous magma. The frequent occurrence of graphite in meteorites also indicates that it is not always of organic origin. Except where igneous rocks are associated with carbonaceous sediments, the amount of graphite in them is usually small, and such occurrences are generally of no commercial importance.

"Graphite has been found in unaltered sedimentary rocks, but in all such cases it is present in small amounts and has not been formed in place, but has been washed or weathered out of older igneous or metamorphic rocks.

"The deposits of crystalline graphite which are of greatest commercial importance are veinlike in form and have apparently been deposited along fractures in the rocks. Foremost among these in size and importance are the famous Ceylon deposits, which are described further on in this report. The deposits near Dillon, Mont., also described in this report, and certain deposits in the counties of Ottawa and Argenteuil,

Quebec, belong to this type. Very little is definitely known in regard to the origin of such vein deposits, although numerous theories have been proposed. It is certain that they were deposited along fracture planes in the rocks, and they were probably formed at considerable depths, but at temperatures which in some cases at least did not exceed 575° C. In some localities they are associated with graphite deposits of contact metamorphic origin and were probably formed during the later stages of such metamorphism.

"Many of the commercially important amorphous graphite deposits were coal beds which have been partly or wholly converted into graphite by the metamorphic effect of intrusive igneous rock magmas. Such is probably the origin of the important deposits of Sonora, Mexico, and the deposits of Turret, Col.

"The large group of so-called disseminated deposits in which the graphite occurs in small flakes disseminated through a foliated rock, usually a crystalline limestone or a schist, is of great importance in the United States, Canada, and Germany. Such deposits have probably been formed by the dynamic metamorphism of sediments which carried carbon in some form scattered through them. Metamorphism by igneous rocks has also played a part in the formation of some of the deposits of this type.

MANUFACTURED GRAPHITE.

"The manufacture of graphite on a commercial scale from various forms of amorphous carbon is conducted by the International Acheson Graphite Company of Niagara Falls, which utilizes electric power generated at the Falls. Dr. Acheson patented the process for the manufacture of graphite by the electric furnace in 1896, and its commercial development has been so rapid that at present the output of artificial graphite is greater than the whole production of natural crystalline graphite in the United States.

"The conversion appears to take place on a commercial scale only when certain impurities, usually siliceous, aluminous, or ferruginous, are present. These need not form more than 3 per cent of the total, but to obtain the best results should be evenly disseminated through the mass. The explanation of the conversion which has been advanced by Dr. Acheson supposes that the amorphous carbon first unites with the siliceous, ferruginous, or other impurities present to form carbides, which are later decomposed with the formation of graphite and the volatilization of the other constituents. The small amount of impurity required to effect the change is explained by supposing that the transfer becomes progressive, vapors of iron or silicon traversing the entire

charge, combining with molecules of amorphous carbon, and then abandoning them in a graphitic state. This explanation is not, however, accepted by all investigators, and recent investigations appear to show that the product obtained in the electric furnace depends fully as much upon the nature of the original carbon used as upon the impurities present.

"Anthracite coal carrying small amounts of evenly distributed impurities is used in the manufacture of the ordinary grades. An anthracite with 5.78 per cent ash is said to have yielded a graphite with only 0.03 per cent of ash, the siliceous impurities being volatilized in the process. For obtaining the purest grades of graphite, petroleum coke is substituted for anthracite. An important part of the industry at Niagara Falls is the graphitization of rods and bars of amorphous nongraphitic carbon for use mainly as electrodes in electrochemical industries. These bars are made by pressing hot through a die in a hydraulic press a mixture of tar and ground petroleum coke. They suffer very little change in size or form in the process of graphitization. The Acheson furnaces have permanent heads for conducting the current. The walls are of loose-brick construction designed to retain the materials in place while the furnace is in operation; when the furnace is about to be unloaded the walls are easily torn down. Coke and sand are used for insulating. Although several furnaces connect with each electric unit, only one is fired at a time, the others being in process of loading, unloading, cooling, or repair. Furnaces for the production of ordinary bulk graphite are run for 12 to 24 hours and are allowed to cool for about four days, reloading taking place about every five days. The carbon rods and bars for electrodes, etc., must be fired much longer.

"Prices for powdered graphite range from 4 cents to as much as 28 cents a pound, according to grade, and for the electrodes, etc., from 10 to 12 cents a pound. Much of the powdered graphite is mixed in proportions varying from 1 to 10 per cent with greases of several degrees of stiffness. . A specially treated graphite which will remain suspended in oil is marketed in a concentrated form in gallon equivalents. When 1 gallon equivalent is mixed with oil to make 1 gallon of material, the mixture contains 0.25 per cent of graphite.

"In spite of the development of the manufacture of graphite by the electric furnace, the demand for the natural product has increased very largely in recent years because of the growth of the iron and steel industry, the largely increased use of copper and its alloys, the increased need for lubricants, and the development of electric machinery which calls for graphitized products.

USES.

"The characteristics possessed by graphite, and already mentioned, make it a mineral of great and increasing industrial importance, but also, as already stated, graphite from any one property is never adapted to all of these uses, its purity and physical character determining its industrial application. One of the oldest and most important applications is in the manufacture of crucibles for use in the steel, brass, and bronze industries, etc. The fact that graphite is nearly pure carbon, is relatively inert chemically, and volatilizes only at high temperatures, make it of exceptional value for this purpose. Such crucibles must have good tensile strength, and the poorer the binding quality of the graphite used the larger the quantity of less refractory binding material which must be added to hold the mass together, thus increasing the more fusible constituents of the crucible at the expense of the more refractory and materially decreasing its life. It is for this reason that a fibrous or flaky graphite is used in crucibles, for the interlocking of these flakes or fibers adds to the tensile strength. Ground Ceylon lump graphite is the material most in favor in the United States for making crucibles, although small amounts of American flake-graphite are also used. Amorphous graphite has never been successfully utilized in crucible manufacture, with the single exception of very small crucibles machined out from manufactured graphite rods or blocks.

"Other refractory products, such as muffles, stirring rods, dipping cups, skimmers, and nozzles, are usually made from materials similar to those used in crucibles, although manufactured graphite products are also on the market for many of these uses and for the preparation of molds for metal casting. Manufactured graphite for such uses is made by treating in the electric furnace amorphous carbon articles previously made up into the desired form. The main use of such graphitized carbon rods and plates is as electrodes in electrochemical industries. They can be machined, threaded, and cut with ease.

"One of the most important uses of graphite is for lubricating. The addition of graphite to oil results in a lower frictional resistance than would be obtained by the use of oil alone. The quantity of oil required for a given service is also reduced and a lighter grade of oil may be employed without decreasing the quality of the lubrication. A small quantity of graphite only is required, and the benefits derived from its use persist long after the application has ceased. In light bearings of machinery, where oil cannot be used on account of the danger of soiling delicate textiles, graphite can be used alone as a lubricant. Both the amorphous and the crystalline varieties of natural graphite are ex-

tensively employed for lubrication, and when used for this purpose should be free from gritty impurities. The percentage of graphite in the better grades of lubricating stock usually exceeds 90 per cent. Lubricating graphite is sometimes marketed as dry flake or powder, but usually as a mixture with oil or grease.

"The use of graphite in the manufacture of pencils is probably both its oldest and its best known application. This industry in Germany and England is several centuries old, and many of the modern factories manufacture hundreds of varieties of pencils, yet the percentage of graphite used for this purpose is not large, being undoubtedly less than 10 per cent of the world's production, and one authority estimates it as low as 4 per cent. In this industry the physical character of the graphite is of great importance. Crystalline graphite, however pure, would, if used alone, yield a 'lead' that would slip over the paper without leaving more than a faint streak. Furthermore, it is almost impossible to grind the easily cleavable flake graphite into a powder of the fineness and evenness of grain requisite for the better grades of pencils. The better grades of amorphous graphite constitute the bulk of the material used in pencil manufacture. For some of the cheaper pencils only one kind of graphite is used, but the graphite for pencils of the better grades is a careful blend of several kinds. One blend, for example, contains about one-third Ceylon graphite, one-third Bohemian graphite, and one-third Mexican graphite. The Ceylon graphite adds to the smoothness of the 'lead'; the Bohemian graphite adds blackness. Graphite when used for pencils is mixed with carefully refined clay, which is usually imported from Germany; no domestic clay has been found entirely suitable for pencil manufacture. The more graphite and the less clay, the softer the pencil; the less graphite and the more clay, the harder the pencil. The cores of softer pencils are usually made larger than those of the harder ones in order to give them equal tensile strength. For a pencil of medium hardness, about one-third clay is commonly used. The wet mixture of clay and graphite is worked and reworked until it is so pliable that it can be looped in coils and even tied in loose knots.

"Up to a few years ago every American pencil manufacturer had to import his graphite from Bohemia or Bavaria. About twelve years ago a large deposit of amorphous graphite was discovered in Sonora, Mexico. This proved to be of excellent quality for pencil making and many other uses, and the American pencil trade now derives its supply mainly from this source. Some Mexican graphite is also exported to European pencil manufacturers.

"A use which has increased rapidly in importance within the last few years is the manufacture of graphite paint, especially for structural

iron and steel work. Much of the graphite used for this purpose is rather impure, the specifications frequently requiring not more than 35 or 40 per cent of graphite in the paint pigment, the remainder being generally siliceous, aluminous, or ferruginous material. Most of the graphite used in paints is of the amorphous variety, but some very fine-grained crystalline material is also employed. Six graphite paints used in tests on the Pennsylvania Railroad bridge at Havre de Grace, Md., showed from 19.16 to 97.80 per cent of graphite in the pigment. Recent tests made in coöperation between the Office of Public Roads of the Department of Agriculture and the Paint Manufacturers' Association, for the purpose of determining the relative merits of various paint pigments as preservative coatings for iron and steel, have yielded results of great importance, with which makers and users of graphite paint should be familiar.

"Large quantities of amorphous graphite and of finely ground crystalline graphite are used for coating molds in foundries. A high degree of purity, though essential for the finest castings, is not necessary in all graphites used for this purpose; in fact, the presence of siliceous material may sometimes be of positive benefit by causing the graphite to cling or spread better on the face of the mold. Considerable amounts both of amorphous graphite and of finely ground crystalline graphite are used in the manufacture of stove-polishing powders and paste. Another use of crystalline graphite is as a protective polish for gunpowder and as a packing material for the delicate electric lamp filaments; it is also used in electrotyping and as a filler for dry batteries."

PRODUCTION.

In the following table is given the production of graphite from 1901 to 1912, inclusive:

Production of Graphite in North Carolina from 1901 to 1912.

Year.	Quantity.	Value.
	Tons.	
1901	95	$ 559
1902	830	4,300
1903	50	248
1904	100	525
1905	100	475
1906	100	475
1907		
1908		
1909		
1910		
1911	120	300
1912		

ASBESTOS.

There are mined and put on the market as asbestos two minerals that are very similar in their physical properties, but are distinct chemically. One, a variety of the mineral amphibole, is a silicate of calcium and magnesium; the other is a variety of serpentine, a hydrous magnesium silicate, and is known as chrysotile. These two varieties of asbestos are equal in their heat-resisting properties, but the chrysotile is superior in strength and elasticity of fiber to any variety of amphibole asbestos. The former is usually greenish-white, green to yellowish in color, with a decidedly silky luster, while the other is from white to greenish and wood-brown in color and has more the appearance of flax. The fibers of the chrysotile asbestos vary from 1-16 to 3 inches in length, while fibers of amphibole asbestos have been found 3 feet in length. The two varieties can readily be distinguished from each other by testing them for water, the chrysotile being a hydrous mineral and giving off a considerable amount of water when heated. The modes of occurrence of these two varieties are distinct, the amphibole variety being usually in granitic or schistose rocks, sometimes in pockets and again in well-defined veins, while the chrysotile variety is found in seams of varying thickness, always in serpentine rocks. For purposes where nonconductivity of heat is the important factor, and not strength of fiber, the amphibole variety can be used, and gives apparently as good results as the chrysotile. On the other hand, where strength of fiber as well as nonconductivity of heat is desired, the chrysotile variety is used, as in the manufacture of cloth, roping, felt, boards, tubes, and washers.

CHEMICAL AND MINERALOGICAL COMPOSITION OF ASBESTOS.

AMPHIBOLE ASBESTOS.

There are a number of minerals belonging to the amphibole group that occasionally assume a fibrous structure and are asbestiform in appearance. Where these occur in quantity, they can undoubtedly be utilized as commercial asbestos; but they cannot be used for the same purposes as the chrysotile variety.

The amphibole that most commonly assumes a fibrous structure is tremolite. This crystallizes in the monoclinic system and its chemical composition is represented by the formula $(MgCa)\ SiO_3$, a magnesium, calcium, meta-silicate. There are nearly always a little iron and alumina present, together with some moisture.

Anthophyllite, the othorhombic amphibole, has been found with a fibrous structure at a number of localities and, as shown by Dr. George

P. Merrill[1], much of the asbestos that is called the amphibole variety (tremolite) is in reality anthophyllite. It is also true that many specimens that have at first been considered anthophyllite have proved upon close examination to be one of the monoclinic amphiboles and in some cases to be an enstatite. The chemical composition of anthophyllite is represented by the formula (MgFe) SiO_3, that is, it is magnesium iron meta-silicate. There are nearly always from a trace to several per cent of alumina and a small amount of moisture found in anthophyllite. Many mistakes of this character have been made in connection with the fibrous minerals occurring with the basic magnesian rocks which extend from Alabama northeastwardly to the Gaspé peninsula in Canada. These, as a rule, occur in very small quantity. Occasionally a pyroxene is observed that has an asbestiform structure, this being more noticeable in the enstatite than in the monoclinic pyroxene.

The following analyses[2] will illustrate the chemical composition of the tremolite and anthophyllite varieties of asbestos, and shows how readily anthophyllite, which contains but a very small amount of lime, can be distinguished from tremolite, which contains over 10 per cent.

Analyses of Asbestos.

	I. Tremolite.	II. Tremolite.	III. Anthophyllite.	IV. Anthophyllite.
Silica, SiO_2	56.96	56.26	56.52	56.21
Alumina, Al_2O_3	.52	1.31	3.57	2.78
Ferrous Oxide, FeO	1.12	6.40	10.18	8.58
Lime, CaO	13.84	11.98	Trace.	.82
Magnesia, MgO	23.90	20.85	27.13	28.95
Manganese Oxide, MnO		Trace.		Trace.
Ignition, H_2O	2.37	2.65	2.96	2.23
Totals	98.71	99.95	100.26	99.31

I. From Parkton, Md.; George P. Merrill, analyst.
II. From Albemarle County, Va ; R. L. Packard, analyst.
III. From Rabun County, Ga.; George P. Merrill, analyst.
IV. From Caldwell County, N. C.; George P. Merrill, analyst.

As is well known, pyroxene suffers alteration very readily, passing over into some one of the amphiboles, and it is not improbable that considerable asbestos was originally a pyroxene. The fibrous structure of these minerals represents a crystalline phenomenon, and the individual fibers may be either distinct crystals more or less perfectly developed in the prismatic zone, or they may be due to abnormal cleavage that has been very highly and perfectly developed. There would be a tendency to distortion in the fibers, due to pressure and other forces to which the mineral may be subjected. In some instances it is undoubtedly true that

[1]Proc. U. S. Nat. Museum, Vol. XVIII, pp. 281-292.
[2]Proc. U. S. Nat. Museum, Vol. XVIII, p. 291.

the fibrous structure has been produced by a process of shearing which has drawn out the mineral parallel to the vertical axis, and in recrystallization it has assumed the fibrous structure.

Dr. George P. Merrill[1] sums up the results of his investigations as follows:

> "The points brought out in this paper and the suggestions advanced are (1) that a very considerable proportion of the mineral in the commercial use, and labeled as asbestos in mineral cabinets, is in reality anthophyllite, and (2) that the fibrous structure in this case and that of the true asbestos as well, is due, in many instances at least, to a process of shearing—is, in fact, an exaggerated form of the process of uralitization."

That a great deal of the amphibole asbestos is the result of the alteration of a pyroxene is undoubtedly true, but it is also true that some of the asbestos represents an original amphibole mineral. It has not yet been definitely determined, however, whether or not this asbestos represents an original crystallization, although there is some evidence that the asbestos is not always a secondary mineral. Dr. Merrill believes "that the asbestos form is never a result of original crystallization, but is always secondary, the original mineral doubtless being an orthorhombic or monoclinic pyroxene, or perhaps an amphibole." As further stated by Dr. Merrill, there is an ample field for investigation along this line, in determining the original character of the different varieties of amphibole asbestos and also their present mineralogical character.

CHRYSOTILE ASBESTOS.

This variety of asbestos is entirely distinct from the amphibole varieties. It is a fibrous serpentine, whose composition is represented by the formula $H_4Mg_3Si_2O_9$, a hydrous magnesium silicate. Chemically, it is readily distinguished from the amphibole varieties by its large content of water. Physically, it is more silky in luster and its fibers are stronger and more elastic. In the table below are given analyses of chrysotile, anthophyllite, and tremolite asbestos.

The fibers of this asbestos are usually perpendicular or at high angles to the walls, but very rarely they have been observed where they are parallel to them. They occur in serpentine, near the source of some local disturbances, as where granitic dikes appear in the serpentine or near the contact of the serpentine with the main mass of the country rock.

At many of the peridotite localities this fibrous variety of serpentine, chrysotile, has been found. Sometimes it occurs but very sparingly, and

[1] Ibid., p. 289.

even where the peridotite rocks are entirely altered to serpentine there is often little or none of the chrysotile variety developed. It has been observed sparingly in small seams in a number of the peridotite rocks that showed but slight alteration to serpentine. Not all of the peridotite formations that have been thoroughly converted into serpentine contain the chrysotile, and but few contain a sufficient amount to make them of commercial importance.

Analyses of Asbestos.

Constituent.	I. Chrysotile, Canada.	II. Anthophyllite, Virginia.	III. Tremolite, Georgia.
SiO_2	40.57	56.52	55.81
Al_2O_3		3.57	1.66
Fe_2O_3	.90		
FeO	2.81	10.08	6.81
CaO		Trace.	12.74
MgO	41.50	27.13	21.09
H_2O	13.55		
Ignition		2.96	1.81
Totals	99.33	100.26	99.92

I. J. T. Donald, analyst.
II. R. L. Packard, analyst.
III. George P. Merrill, analyst.

Mr. J. S. Diller of the United States Geological Survey considers asbestos as occurring in three types: cross-fiber, slip-fiber, and mass-fiber. The most important of these is the cross-fiber type, which is almost invariably fibrous serpentine (chrysotile), and occurs in veins in which the fibers run directly across the vein. The slip-fiber type is occasionally the chrysotile asbestos, and this is especially true where it is found in the basic magnesian rocks. Generally, however, slip-fiber asbestos is an amphibole. It occurs in veins on planes along which the rock has slipped in the process of mountain building. The mass-fiber type is the anthophyllite variety of asbestos, and the fibers occur in smaller groups or bundles of parallel fibers, the bundles lying in all positions through the rock of which they form the entire mass. This is the type of asbestos which is mined at Sall Mountain, Georgia. A similar occurrence is near Cane River, Yancey County, N. C.

DISTRIBUTION.

North Carolina.—There are a number of localities in North Carolina where the chrysotile variety of asbestos has been found, the most promising of which are in the vicinity of Glenville and of Sapphire, Jackson County; near the mouth of Squirrel Creek on North Toe River, along

the western slopes of Rich Mountain in Watauga County; on Elk Creek in Ashe County; and near North Wilkesboro, Wilkes County. At these localities fiber of fair length and fineness has been found which warrant further investigation.

The deposit near North Wilkesboro is within three-quarters of a mile of the railroad and occurs in a serpentine formation that is from 75 to about 200 feet in thickness and can be traced in a general NW.-SE. direction for nearly 600 yards. The deposit has been worked by means of an open cut 100 feet long which was made on the land of Mr. J. B. Church. The cut varies in depth from 1 to 35 feet, and near the surface the serpentine encountered was much decomposed and altered, but at lower depths a compact, dark-green rock was found. This harder rock is similar to a bold outcrop of the serpentine that occurs on a low hill about 300 yards a little east of south of this cut on the land of Mr. G. W. Hinshaw of Winston, N. C. A similar outcrop of serpentine was observed on the summit of a hill 200 yards nearly north of the cut. In nearly all of this serpentine small seams of chrysotile asbestos were observed that varied in thickness from a quarter of an inch to nearly 2 inches, the thicker ones having been found in the bottom of the cut. These seams run at all angles through the rock, and as the unaltered serpentine was encountered, the quality of the asbestos became better. Sufficient work has not been done to demonstrate the value of this property as a source of asbestos.

Asbestos is found sparingly in all the enstatite rocks of this northeastern portion of the belt, but it is not probable that it occurs in quantity in these rocks. At many of the other peridotite outcrops besides those mentioned above, chrysotile of good fiber has been sparingly found, but there are no indications that it occurs in quantity. A fibrous enstatite and anthophyllite that closely resemble asbestos have been found at a number of the corundum mines. It is, however, only the chrysotile asbestos found in these peridotite rocks that is worthy of investigation.

A large proportion of the asbestos mined is operated by those who make the manufactured products, so that in opening up new asbestos deposits, unless it is of exceptional quality and of the chrysotile variety, it is hard to find more than a limited market for the new product.

In the Southern States the principal asbestos is of the amphibole variety, either the mineral anthophyllite or the mineral hornblende. It would seem that, if those interested in the development of such asbestos properties would undertake the erection of a manufacturing plant and utilize their raw products, they would be in a position to compete with those manufactured by other companies producing their asbestos from

Canada and other localities, and thus be able to very largely increase their production of raw materials. The amphibole variety of asbestos cannot be used for those purposes where it is necessary to have spinning fiber, but it can be utilized for all the other purposes for which asbestos is desired. During the past two years there has been an increased demand for the lower grades of asbestos which are being used in the manufacture of various forms of building materials. Asbestos shingles made out of asbestos combined with cement are coming very much into favor, and they should be as fireproof as tile shingles, and ought to be a great deal cheaper. There is considerable asbestos in North Carolina that it is believed would be of value for the manufacture of such shingles. Amphibole asbestos should also find a market in the manufacture of various forms of plaster.

During 1911 and 1912 prospecting was carried on for asbestos near Plumtree, Avery County, and Adako, Caldwell County.

RARE METALS.

Associated with pegmatites of Mitchell and Yancey counties are several rare minerals which have commercial value. The most interesting of these is the mineral uraninite.[1]

This mineral is commonly known as pitchblende, and is a uranate of uranyl and lead, with usually some thorium or zirconia. This mineral alters very readily, changing first to a hydrated mineral, known as gummite, which has a greasy luster, and a reddish-yellow to orange color. Further alteration of the mineral is to uranophane or uranotil, which is found in masses of fine fibrous structure, and of honey-yellow to lemon-yellow color. During the past two years uraninite, or pitchblende, has been obtained as a by-product in feldspar or mica mining from the following mines in Mitchell County: Deer Park, Bailey No. 1, near Penland; Eagle Bluff No. 1, near Mount Mitchell postoffice; Blue Rock, 7 miles southwest of Spruce Pine; Beaver Creek Mine, 3 miles northeast of Spruce Pine; Flat Rock Mine, 3 miles from Spruce Pine; and the L. A. Berry, Wiseman, and Deake mines, within a mile or two of Spruce Pine. In all cases the uraninite was partly or wholly altered. Usually there was a core of uraninite surrounded by a ring of orange-colored gummite; this in turn surrounded by a similar ring of bright lemon-colored uranophane.

During 1911 and 1912 there were several hundred pounds of uraninite produced, about an equal amount for each year. There is no regular market for the uraninite from these mines, and the price obtained de-

[1]Economic Paper No. 9 of the North Carolina Geological and Economic Survey, p. 49, 1905.

pends upon the individual who has the material for sale. Some is sold as high as $5 per pound, but the bulk of it does not bring over $1.50 per pound.

Another mineral that is found associated with mica and feldspar of the Mitchell and Yancey counties pegmatites is samarskite, which is also a uranium-bearing mineral. It is a tantalate of uranium, cerium, and yttrium metals, with smaller amounts of iron and calcium. There is a small demand for this mineral for experimental purposes, and it has brought 25 cents to $1 per pound.

STONE.

The development of the stone industry in North Carolina has been most interesting, and the production has increased almost constantly from year to year since the industry began to be thoroughly advertised, and various stones became known. In 1897 the value of the stone produced in North Carolina was less than $75,000. In 1912 the total production of stone has reached $1,090,831, and this has been due almost entirely to the increase in the production of granite. This is an increase of over $200,000, as compared with the production of $864,071 in 1911. There is included under the head of *Stone* all granite, no matter for what purpose it is used; sandstone, marble, and other forms of limestone, including that which is made into lime or used as limestone for agricultural purposes. In recent years another use for stone, which had added greatly to the production, is for making concrete. A large proportion of the stone from some of the quarries is used entirely for this purpose.

In the table below there is given the value of the production of the various stones produced in North Carolina from the year 1900 to 1912, inclusive:

Production of Building Stones in North Carolina, 1900-1912.

Year.	Granite.	Sandstone.	Marble and Limestone.	Total Value.
	Value.	*Value.*	*Value.*	
1900	$ 257,962	$ 27,210	$ *	$ 285,172
1901	264,906	11,682	8,357	284,945
1902	338,749	4,825	23,153	366,727
1903	334,357	600	25,365	360,322
1904	292,439	250	19,887	312,576
1905	564,425	4,482	29,015	597,922
1906	778,819	3,431	72,051	854,301
1907	906,476	4,105	46,338	956,919
1908	771,522	†	53,405	824,927
1909	743,876		106,931	850,807
1910	837,742	†	77,585	920,027
1911	772,685	†	81,651	864,071
1912	983,615	†	100,766	1,090,831

*Statistics not collected for 1900. †Included in total production.

A. Mount Airy Granite Quarry, showing blocks of stone which have been cut off.

B. Mount Airy Granite Quarry, showing method of conveying blocks of stone by cable.

GRANITE.

MOUNT AIRY GRANITE.[1]

At Mount Airy, Surry County, North Carolina, is one of the largest granite quarries in the South, and it offers possibilities of becoming the largest quarry in the country. (Plate X, A and B.) Openings have been made in a 40-acre tract of nearly continuously exposed granite over the slope and top of a long hill which rises to an elevation of about 125 feet above the level of the valley, in which a railroad track is laid and operated between the quarries and Mount Airy, where it connects with the Southern Railway. The distance between the extreme openings on this ridge in an east and west direction is approximately 3,000 feet; in width, openings have been made for about 800 feet. The deepest workings have a depth of about 30 feet, from which four or five raises of the rock of different thicknesses have been removed. The average angle on slope of the exposed granite from the base to the top of the hill is 12 degrees, and this is readily taken advantage of in facilitating easy quarrying. Veins and dikes, usually found in most granites, are nowhere visible in the Mount Airy quarries. The rock is very light gray, nearly white, biotite granite of medium texture, containing no visible injurious minerals. It is very uniform in color, and the limit of dimension of stone is the capacity of a railroad car. To illustrate the size of blocks that can be obtained, there was taken out of the quarry and sent to the Jamestown Exposition a block of granite weighing 57 tons. It was nearly rectangular in shape, and was not trimmed in any way, but shipped exactly as quarried. The equipment in the quarries consists of nine cableways with a maximum capacity of 8 tons each; two inclines of 60 tons capacity each, and a complete outfit of channelers, plug drills, and other equipment.

It was at the Mount Airy quarries that the method of quarrying by means of compressed air was developed. (Plate XI, A and B.) Formerly a quarry was opened by blasting with powder. This was superseded by the method of quarrying by water, which was used until 1903. This method consisted of drilling a hole about 3 inches in diameter perpendicular to the surface to the depth of thickness of the stone desired, usually 5 to 7 feet, and then firing a succession of light blasts, using in the first charge about a handful of blasting powder, beginning the operation with about one-quarter of a pound of dynamite in the bottom of the hole. This small percentage of dynamite pulverized the stone slightly at the bottom of the hole and formed a small chamber.

[1] Manufacturers' Record, May 29, 1913, p. 59.

The tamping was then cleaned out of the hole and it was recharged in the same manner, this time, however, using about a handful of powder. Recharging of the hole was continued with small charges of powder until a small seam had been started at the bottom of the hole extending parallel with the surface. This was ascertained by using a small steel rod, bent at the lower end and sharpened to a point, by passing it up and down the hole until the crack was located. After the crack was once started, the use of light charges of powder was continued, the charges being gradually increased as a seam was found to extend in all directions from the lift hole until the crevices extended a distance of 75 feet or more from the hole. The use of explosives was then discontinued and a water-tight connection was made to the hole by cutting off a piece of iron pipe of suitable length, which was fastened in the hole with melted sulphur. To this connection was attached an ordinary hand-force pump, with which water was forced into the crevices already formed by the explosives. No difficulty was found in extending the crevices by continuous pumping of the water until finally it covered an area frequently as much as 2 acres in extent and found vent by tearing out to the thin edges on the side of the hole. This process was only used in the warmest weather, when the surface of the rock was naturally somewhat expanded and more easily raised. It was never tried in cold weather, and it is doubtful whether good results could be obtained in such weather.

Although the North Carolina Granite Corporation, operating the Mount Airy quarries, found that the substitution of water under pressure for powder after the cleavage had extended some little distance from the drill hole was an improvement, they were not satisfied with the results, and began experimenting with compressed air, with the result that they found the compressed air was an improvement over water as the water was over powder.

In the center of the sheet or area to be lifted a drill hole 2 to 3 inches in diameter is sunk 6 to 8 feet in depth, depending on the greatest thickness of stone required, and the operation is continued by the discharge of successive small amounts of powder similarly as described under the method of quarrying by using water until the crevice extends a distance of 75 feet or more from the hole in all directions. A pipe is then cemented into the hole and connected by means of a globe valve to an air-pipe line from an air compressor. Compressed air at 70 to 80 pounds pressure is gradually admitted and the cleavage rapidly extended until it comes out upon the hillside in a thin edge. A sheet of several acres in extent may be raised in this manner, affording a bed

A. Mount Airy Granite Quarry, showing methods of quarrying by means of compressed air.

B. Blocks of stone ready for carving at Mount Airy Granite Quarries shop.

plane approximately horizontal, to which the quarrymen can work, thus securing stone of any required thickness. The first time compressed air was used a pressure of 80 pounds was admitted into the vacuity which had previously been extended to a distance of 100 feet from the lift hole. The power of the air, however, was too great for the easily splitting stone, and the cleavage turned abruptly to the surface. In the next hole, however, the compressed air was admitted very gradually, and the stone could soon be heard cracking in all directions, and in about half an hour the cleavage came to the surface of the hillside as a thin edge some 225 feet from the lift hole. To extend the cleavage by means of powder for 100 feet would require from six to twelve days, and with water, from three to five hours, while with compressed air the large area was split in half an hour. This method is still in use, and giving splendid satisfaction.

By this and other economical methods of operation the North Carolina Granite Corporation is able to produce granite for building and paving purposes at a price comparing favorably with any quarry in the country.

There are two crushing plants, one having a capacity of about 200 tons per day and the other 500 to 1,000 tons per day, depending upon the size to which the product is crushed. This latter plant was installed about a year ago, and is equipped with boiler (capacity 300 horse-power); Hamilton Corliss engine (capacity 250 horse-power); a Sullivan two-stage air compressor of 1,000 feet capacity; a No. 7½ and No. 5 Gates crusher, and two sets of Sturtevant balanced crushing rolls, with the necessary screens, elevators, bins, etc. Stone is supplied to this plant by small cars from the quarries, which dump into the hopper automatically. The main finishing plant is equipped with boilers of 420 horse-power; a Sullivan cross-compound Corliss air compressor of 2,000 feet capacity; a 100-kilowatt generator direct connected to an Ideal double-cylinder engine; two 20-ton Pawling and Harnischfeger electric cranes, 50-foot spat, each equipped with 5-ton auxiliary hoist; one 14-foot column lathe, and one Jumbo polishing mill, with about 15 surfacing machines. For handling the stones from the quarries to the finishing plant a regular three-driver shifting engine is used.

The North Carolina Granite Corporation, which operates the Mount Airy quarries, is the largest producer of granite in the State. The next largest producer is the Harris Granite Quarries Company. This company has quarries in Rockingham and Rowan counties. A large proportion of their granite is made into paving blocks.

PRODUCTION.

During 1911 there were twenty-six operators who worked twenty-eight quarries in the following eleven counties, given in the order of the importance of their production: Surry, Rowan, Rockingham, Mecklenburg, Buncombe, Warren, Vance, Polk, Henderson, Cabarrus, and Wilson. The value of the 1911 production was $772,685.

In 1912 there were thirty-two operators who worked thirty-four quarries in the following fourteen counties, given in the order of the importance of their production: Surry, Rowan, Mecklenburg, Buncombe, Rockingham, Vance, Warren, Polk, Halifax, Wake, Guilford, Gaston, Henderson, and McDowell.

The large increase noted in the value of the production of 1912 over 1911 is due principally to the amount of granite reported as being quarried and used in concrete. One very interesting change to be noted in the granite industry for 1912 was the large increase of granite that was quarried and used for building and monumental purposes. In the following table there are given the uses and value of granite produced from 1908 to 1912, inclusive:

Uses of Granite Produced in North Carolina in 1908-1912.

Uses.	1908.	1909.	1910.	1911.	1912.
Building and monumental purposes	$330,836	$249,511	$268,372	$180,283	$ 315,088
Paving blocks	122,488	214,508	164,265	192,841	212,990
Curbing and flagging	107,328	99,386	113,778	215,920	135,016
Crushed stone for road making, railroad ballast, etc.	153,749	78,605	291,327	159,747	105,879
Concrete					206,579
Other purposes	49,871	*101,866	2,000	23,894	8,063
Total value	$764,272	$743,876	$839,742	$772,685	$ 983,615

*Principally for concrete.

The next table gives the value of granite produced from 1897 to 1912, inclusive, and shows very strikingly the remarkable growth of this industry in the State. The 1912 production is the greatest production of granite reported for any year:

Production of Granite in North Carolina, 1897 to 1912.

Year.	Value.	Year.	Value.
1897	$ 59,236	1905	$ 564,425
1898	79,969	1906	778,819
1899	225,544	1907	906,476
1900	257,962	1908	764,272
1901	264,906	1909	743,376
1902	338,749	1910	839,742
1903	334,357	1911	772,685
1904	292,439	1912	983,615

A. Manufactured product from Mount Airy Granite Quarry, showing columns, etc.

B. Sample of Mount Airy granite after carving.

PRODUCERS.

There is given below a list of those who reported a production of granite during 1911 and 1912:

French Broad Quarry and Building Material Company, Asheville, Buncombe County.

Ardmion Park Quarry Company, Asheville, Buncombe County.

Balfour Quarry Company, Asheville, Buncombe County.

Gudger & Pritchard, Asheville, Buncombe County.

J. B. Lotspeich, Weaverville, Buncombe County.

West Asheville Quarry Company, 14 Park Square, West Asheville, Buncombe County.

Charles M. Friday, Dallas, Gaston County.

William Lockhart & Hoffman, Gastonia, Gaston County.

Brown & Albright, Greensboro, Guilford County.

Winston-Salem Soutbound Railway Company, Newsom, Davidson County.

Wright & Dixon, Hendersonville, R. F. D., Henderson County.

W. T. Morgan, Marion, McDowell County.

Atlantic Bitulithic Company, Charlotte, Mecklenburg County.

Charlotte Quarry Company, Tryon, Polk County.

Harris Granite Quarries Company, Salisbury; quarries in Rowan and Rockingham counties.

Blue Pearl Granite Company, Winston-Salem; quarries in Rowan County.

J. T. Artz, Salisbury, R. F. D. No. 3, Rowan County.

E. A. Brown, Salisbury, R. F. D. No. 3, Rowan County.

Faith Granite Company, Salisbury, R. F. D. No. 3, Rowan County.

M. G. M. Fisher, Salisbury, R. F. D. No. 3, Rowan County.

W. B. Stirewalt, Salisbury, R. F. D. No. 3, Rowan County.

Byrd Brothers, Salisbury, R. F. D. No. 3, Rowan County.

D. A. Hodge & Co., Salisbury, R. F. D. No. 3, Rowan County.

Kirk Mountain Granite Company, care Bowden & Eames, Salisbury; quarries in Rowan County.

B. & W. Granite Company, Granite Quarry, Rowan County.

John T. Wyatt Granite Company, Salisbury, R. F. D. No. 3, Rowan County.

C. C. Wyatt, Salisbury, R. F. D. No. 3, Rowan County.

N. C. Granite Corporation, Mount Airy, Surry County.

P. Linehan & Sons, Grey Stone, Vance County.

R. J. Southerland, Henderson, Vance County.

Linehan-Carroll & Co., Middleburg, Vance County.

The Granita Company, Raleigh; quarries Knightdale, Wake County.

The Cooper Quarry, Raleigh, Wake County; address R. G. Lassiter, lessee, Oxford, N. C.

The Wise Granite Company, Wise, Warren County.

Atlantic Coast Line Railway Company, Elm City, Wilson County.

Wilson Light and Power Company, Wilson, Wilson County.

SANDSTONE.

Sandstones in North Carolina that have been quarried are from the Triassic sandstone extending across the State in varying widths and covering portions of Granville, Durham, Orange, Wake, Chatham, Harnett, Lee, Moore, Montgomery, and Anson counties. There is a similar belt of this sandstone which extends across a part of Rockingham, Stokes, and Forsyth counties. The color of these sandstones varies somewhat throughout the belt, but it is usually a reddish-brown and rather grayish-brown.

Brown stone, as this red sandstone is known on the market, was formerly one of the favorite building stones; but for the past ten years the demand has been growing less and less for this stone, and this is one of the reasons why this industry has not been developed to any large extent in this State. Other drawbacks to successful quarry development have thus far been the abundant jointing of the beds whereby the stone is broken into blocks of comparatively small size, and a lack of uniformity in color of the various beds. There is no doubt that the chief reason for the lack of demand for brown stone is the change in public taste. This is true not only of the North Carolina stone, but of all brown stones in various regions throughout the United States, where formerly there were large quarries supplying brown stones for the construction of buildings in nearly all of the larger cities. These are now idle and their equipment nearly destroyed.

In 1911 there was one producer of sandstone who operated quarries in Lee County; in 1912 there were two producers operating quarries in Lee and Anson counties. The figures regarding the production of sandstone are given in the table, which shows the total production of stone in North Carolina. The producers of sandstone during 1911 and 1912 were:

PRODUCERS.

Carrington-Gonella Stone Company, Sanford, Lee County.

John T. Patrick, Wadesboro, Anson County.

MARBLE AND OTHER FORMS OF LIMESTONE.

MARBLE.

In the report on the Mining Industry of 1910 a detailed description of the marbles of the Nantahala area was given. Since that year considerable advance has been made in the marble industry of the State, not only in the utilization of this stone for building purposes, but also for burning into lime. Most of the marble of this area is magnesian marble.

The largest quarry of North Carolina marble is located at Regal, Cherokee County, near Murphy. There is a growing demand for "Regal" marble. When this marble was first quarried, there was considerable difficulty in obtaining blocks of sufficient size for building and monumental purposes on account of excessive jointing that was developed in the quarry. With depth, however, these joints have seemed to grow less and less, and at the present time the quarry is yielding very much higher percentage of merchantable marble than in any previous history of the mine. As reported by the company, they frequently now obtain blocks containing 150 cubic feet without a single defect. Plate XIII A will give an idea of the size of the blocks of marble that are being taken out of this quarry. Plate XIII B shows the quarry as it has been developed. Practically all of this marble has been used for building and monumental or ornamental purposes.

The Kinsey marble occurs in a belt of marble in the vicinity of Kinsey, about 6 miles southwest of Murphy, and has not been quarried to any great extent during the past few years. That which has been quarried in the last two years has not been used for building or ornamental purposes, but as a flux in copper smelting.

The Nantahala marble, which occurs in Swain County in the vicinity of Nantahala and Hewitts, has not yet been developed for building purposes. Considerable of this marble has, however, been quarried and used for the manufacture of lime for use in pulp mills and for macadam and concrete work.

The production of marble is included in that of limestone.

The following were producers of marble during 1911 and 1912:

PRODUCERS.

The Casparis Marble Company, Regal, Cherokee County.
The Kinsey Quarries, Kinsey, Cherokee County.

LIMESTONE.

Limestone produced in North Carolina in 1911 was obtained from the following counties, given in the order of importance of their production: Henderson, New Hanover, Craven, Beaufort, Columbus, Yadkin, Jones, and Transylvania.

In 1912 the counties producing limestone, in the order of importance of their production, are given below: Henderson, Madison, Craven, New Hanover, Columbus, Beaufort, and Jones.

The limestone produced in these counties is used for five distinct purposes: for burning into lime for use in making mortar; for fertilizer purposes and in pulp mills; as crushed or ground limestone for use as fertilizer; as crushed limestone for chicken grit; and as crushed limestone for road building in concrete.

PRODUCTION.

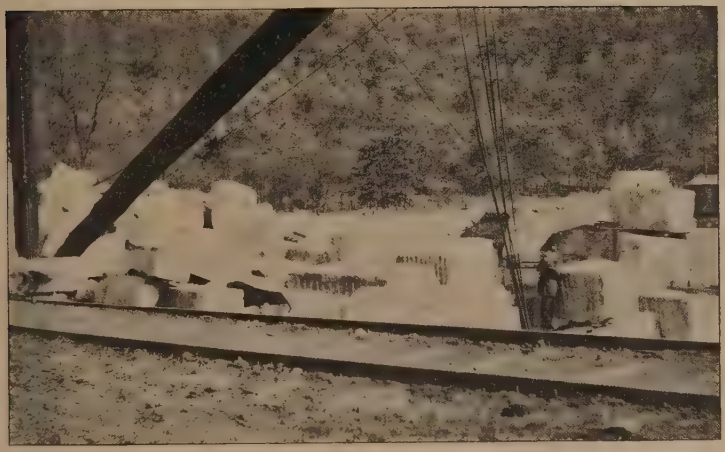
There is given in the table below the value of the production of marble and other forms of limestone from 1901 to 1912, inclusive:

Production of Marble and Other Forms of Limestone, 1901-1912.

Year.	Value.
1901	$ 8,357
1902	23,153
1903	25,365
1904	19,887
1905	29,015
1906	72,051
1907	46,338
1908	53,405
1909	106,931
1910	77,585
1911	81,651
1912	100,766

PRODUCERS.

The following were the producers of limestone in 1911 and 1912:
Southern Lime and Fertilizer Works, Washington, Beaufort County.
The Carolina Coast Lime Company, New Bern, Craven County.
The Chemical Lime Company, New Bern, Craven County.
The Beaver Creek Lime Company, Kinston; quarries Jones County.
The Blue Ridge Lime Company, Fletcher, Henderson County.
The G. C. Buquo Lime Company, Hot Springs, Madison County.
B. F. Keith, Wilmington; quarries Columbus County.
The County Commissioners of New Hanover County, Wilmington.



A. Shows portion of yard of the Regal Marble Company, with blocks of marble.

B. Shows the Quarry as it has been developed.

The North Carolina Talc and Mining Company, Hewitts, Swain County.

W. A. Baynard, Brevard, R. F. D. No. 2, Transylvania County.

Yadkin Lime Company, Winston-Salem; quarries Yadkin County.

SAND AND GRAVEL.

USES AND DEFINITIONS OF SAND.[1]

"Sand is defined as any hard, granular, rock material finer than gravel and coarser than dust. It may have been comminuted either naturally or artificially. Quartz grains generally predominate in natural deposits, although such deposits commonly contain many other minerals.

"Gravel consists of small stones or pebbles, or a mixture of sand and small stones. Specifically, it is fragments of rock worn by action of wind and water, and larger and coarser than sand.

"Sand is classified in various ways: (1) By size, as fine, medium, and coarse; by composition, as siliceous, calcareous, ferruginous; (2) by origin, as eolian, river, glacial, lake, beach; (3) by use, as glass, engine, molding, and filter. Classification by use is the one by which the United States Geological Survey tabulates statistics of production. It should be borne in mind that the same sand in many cases answers for a variety of purposes, and in this case one and the same thing has several names. As an example, a New Jersey dune sand is sold to filtration plants for filter bed, to local masons for building or mortar sand, to foundrymen for core sand, and might be used for engine sand, paving sand, or other purposes. Gravel also assumes various names, depending on its use. One size of gravel is shipped from one plant for filter bed, sand blast, roofing, concrete, and asphalt paving. A high-grade silica sand is glass sand to a glassmaker, steel sand to a steel molder, grinding sand to a stonecutter, asphalt sand to a pavement contractor, facing sand to a concrete-block maker, and furnace sand to a foundryman.

"The following definitions, alphabetically arranged, illustrate a few of the uses to which sand is put:

"Asphalt sand is the term used by some producers to designate a clean siliceous sand of medium grain and sharpness used for mixing in the body and making the face of asphalt pavement and asphalt paving blocks.

"Bedding sand is scattered over the floor of cattle cars for sanitary purposes. Any fine, clean sand is suitable.

[1]From Advance Chapter of Mineral Resources of 1912.

"Blast sand is clean, tough, sized sand, either round or angular grains, used by compressed air for such purposes as cleaning metal castings and dressing stone.

"Brass sand is an exceedingly fine sand used in making molds for casting aluminum, brass, and bronze on which a very smooth surface is desired. It has a strong bond, but is so fine grained that its permeability is slight and care has to be taken to avoid 'blowing.'

"Building sand is used for making mortar and concrete and sand-lime brick. For best results it should be siliceous, clean, free from salts, as sharp as can be obtained at a reasonable cost, dry, and should not contain more than 10 per cent by weight of clay or loamy material. Sand used for mortar should pass a No. 10 sieve and 80 per cent of it should be retained on a No. 74 sieve.

"Core sand is a coarse molding sand used to make a solid form, usually porous, to be placed in a mold, about which the metal is poured, so as to be cast hollow. Permeability is the special quality required.

"Engine sand is used on locomotives and street cars to keep the wheels from slipping on wet or slick rails. The principal requirements are that the sand be of hard minerals, preferably quartz, sharp, clean, dry, and fairly fine and even grained, so that it will run freely through the conductor pipe.

"Facing sand is a molding sand used to make the face of the mold, the term being used when the material composing the face is different from the body of the mold. Sand used for facing the mold of a heavy casting may be equally well adapted for making all of the mold for a lighter casting.

"Filter sand is clean silica sand in sorted sizes, used for beds in water-filtration plants and in small mechanical filters. It must be free from lime, clay, and organic matter.

"Fire sand is a highly refractory silica sand, for lining furnaces and ladles used to contain molten metal; furnace sand is another name for the same thing.

"French sand is a very fine, open, sharp, yellow sand imported from France for making molds for statuary, brass and bronze work.

"Furnace sand is a highly refractory silica sand used for lining and patching reverberatory and other furnaces, cupolas, and ladles used to contain molten metal. As pure silica sand is noncohesive, some binder is added to give bond. Furnace sand is also used for making runners for pig-iron casting.

"Glass sand is the major constituent of glass, constituting from 52 to 65 per cent of the original mixture. As the quality of the glass depends

largely on the quality of the sand, high-grade glass sands are over 99 per cent silica (SiO_2). Glass sand should be nearly white in color, of medium fineness (passing a 20- to 50-mesh horizontal sieve), the grains should be uniform in size, even, and angular, or, less preferably, they may be rounded.

"Grinding and polishing sands are sharp, tough, hard sands, free from clay or foreign material, and sized, for use in sawing, cutting, and polishing stone, and for grinding and etching glass. The size of the sand varies with the character of the material to be worked on and the kind of work to be done.

"Molding sands are siliceous sand materials used in foundries for making molds and cores for casting metal. They vary from loamy clay to clean silica sand or gravel, the character of the material used depending on the kind of metal to be poured, the size of the casting, the surface desired, and the place in the mold where the sand is to be used. Molding sands should be high in silica to be sufficiently refractory, should have a strong bond when moist, and should have less than 1 per cent of iron oxide. Some molding sands lack bond and are tempered by the addition of a small amount of clay or other binding material. Sand used for dusting brick molds to aid in separating the brick from the form is called molding sand, but should more properly be termed a "parting sand" to distinguish it from foundry molding sands.

"Parting sand is a noncohesive sand with which the meeting faces of a mold are dusted to prevent their sticking together, and with which brick molds are dusted to aid in separating the form from the mold. It is a fine sand free from clay.

"Paving sand is a designation applied to sand used in various ways in road and walk making. Besides the common use on country roads, sand is used for cushion foundation for brick pavement, as the body and facing of asphalt paving, as a part of the composition of concrete and cement walks, as bedding for cobble pavement, and in other ways. For some of the uses almost any convenient sand is suitable, but for others special properties are required. See asphalt and building sand.

"Railroad-ballast sand and gravel have usually but one requirement, bulk, although coherence is a desirable quality. Sand and gravel that will pack and set are preferable. For surfacing tracks gravel or crushed stone is used to reduce the amount of dust raised by passing trains, and in some places to keep the material from being carried away by high winds.

"Silica sand is composed largely of quartz and is obtained from banks of unconsolidated material and by crushing sandstone. It is used for

many purposes, including making glass, lining furnaces and ladles, molding steel, filters, facing concrete and asphalt, as an abrasive (both sandblast and sandpaper), and for fire brick, scouring soap, etc.

"Steel sand is a molding sand used for casting steel. A high degree of refractoriness is required, and therefore a white clean quartz sand about 99½ per cent silica is used. As sand of this character has no bond, in order to make a mold with it a small quantity of siliceous clay, molasses, or other material is added for binder. The size of grain used varies with the weight of the casting and the place occupied in the mold.

"Torpedo sand is a trade term used locally in the Central States for a coarse building sand.

"Other uses to which sand and gravel are put are for chicken grit, pebble dash, sandpaper, sanding woodwork, sand-lime brick, etc.

MOLDING SAND.

"Molding sand production is reported from 30 States. The large producers in order of rank are: Ohio, Pennsylvania, New York, and Illinois, with an output in 1912 of more than one-half million tons each. New Jersey takes fifth place, with 459,397 tons, and Indiana is sixth, with 243,766 tons.

"Foundry sand is an inclusive term for molding, core, and steel sands, all of which are properly described as molding sand because they are used in making molds for casting metal. Sand used to make a core in any particular mold differs so much from that employed in the rest of the mold that it is distinguished as core sand, while sand used as the core for a light casting may be equally well used for the mold of a heavier casting. Steel sands are so very different from ordinary molding sands that, although used for making a mold, they are given the more distinctive name.

"The principal requisites of a molding sand are cohesiveness, refractoriness, texture, permeability, and durability. They may be discussed briefly as follows:

"Cohesiveness is the quality of holding together. A slightly moistened molding sand tamped into a mold must hold together so strongly that when the pattern is removed the grains will stick together and preserve the shape of the pattern, and also will resist the pressure of molten metal when poured into the mold, and its corrosive action while flowing in. Many core sands and all steel sands are deficient in cohesiveness or bond, and binder is supplied by the addition of clay, molasses, flour, or other material. Molding sands get their cohesiveness largely from the clayey material which they contain.

"Refractoriness is infusibility or not melting when subjected to a high degree of heat. A molding sand must be so refractory that it will not melt or fuse and close the pores when molten metal comes in contact with it. The sand must remain sufficiently open to allow the gases to escape. Steel sand is subjected to so much higher heat than other molding sands that a very siliceous material is required, and therefore sand running above 97 per cent silica is used.

"Texture in sand refers to the size of grain or percentage of grains of different sizes. This is an important quality in foundry sand, for it affects the cohesiveness and permeability, as well as determining to some extent the size and weight of casting that can be made and the character of the surface produced.

"Permeability is the property which the sand possesses of allowing a gas or liquid to filter through it. This property depends on the size of the pores or open spaces between the sand grains. Porosity is the volume of pore space. This is not the same as permeability, for sand having a few large open spaces through which a liquid or gas could easily escape may have only a small total pore space; on the other hand, a sand may have a large total pore space, but be almost impermeable on account of the small size of the pores. Permeability is decreased by tamping, and sands of different sized grains pack closer than those in which the grains are of the same size.

"Durability in a molding sand is a desirable quality, especially when the sand used is expensive. A sand which dehydrates and loses its bond slowly or only after being used several times is preferred to one that burns out or becomes 'dead' with one heating. Some sands can be used several times without treatment, and others can be used repeatedly by the addition of a small quantity of fresh sand.

"Chemically, molding sands are siliceous, and those used for iron work commonly contain 75 to 85 per cent silica, 5 to 13 per cent alumina, less than 5 per cent of iron oxide, rarely more than 4 per cent of combined water, and usually less than 2½ per cent of lime and magnesia. A higher percentage of iron and lime is not objectionable in a sand for brass molding.

"As the principal requirement of a core sand is permeability, and as a high alumina or clay sand fuses readily and stops the passage of gas or steam generated in casting, it follows that a core sand as a rule should be high in silica and low in alumina. While some sands and gravels in the raw state are adapted to use in cores of various sizes, it is common practice to make core sand by mixing ingredients. In many cases a

highly refractory material suitable for a core sand is readily available, and needs only the addition of a binder to make it usable. In the case of gravels for large cores, such as iron pipe, coherence or bond is obtained by the addition of loam, clay, or molding sand of strong bond. The permeability is sometimes increased by mixing rye straw in the core sand or by winding the core with rope made of swamp hay. In small cores it is customary to use coarse sand, which insures sufficient permeability, and to add to it a small quantity of clay or molasses water for bond.

"The principal requirement of the steel sand is refractoriness, because the temperature of molten steel is considerably in excess of the temperature of the molten iron or brass. In order to obtain sufficient refractoriness, it is necessary to use almost chemically pure silica sand. The grain of the sand varies with the size of the casting and with the smoothness of surface desired. Ordinary glass sand, silica sand, and some furnace sands are adaptable to use in steel molding by the addition of a binder.

"From the foregoing statements it will be seen that it is difficult to formulate a comprehensive definition of molding sand. The variety is great, ranging through many degrees of each of the required properties. Most molding sands are cohesive, some strongly so, but others are wholly lacking in this property, and require the artificial addition of bonding material. Refractoriness varies from so low that a sand burns out with one using to so high that the sand can be used repeatedly. Permeability ranges widely, and molding sands differ from coarse to exceedingly fine. The colors vary from white and yellow to brown and red.

"Molding sand in place possesses for the most part relatively little intrinsic value. The cost of excavation and preparation makes the market value, to which should be added freight rates. Although many molders insist on sand from a particular locality, others are learning that sand equally well adapted to a special purpose can be obtained at several places."

GLASS SAND.

One of the principal constituents used in the manufacture of glass is sand, and there are many localities in North Carolina where it is believed sand of suitable quality exists that can be used in the manufacture of glass. It is also possible to utilize some of the quartz obtained as a by-product in mica mining for this purpose, provided it can be prepared for use at a low cost.

DEFINITION OF COMPONENTS OF GLASS.[1]

"Glass is a fused mixture of the silicates of alkalies, alkaline earths, and of more common metals. Usually the alkaline bases are sodium and potassium, the alkaline earth is calcium, and the common metallic element is lead. All of these are used in the form of salts. In melting together the various ingredients employed in the batch or mixture, it appears that silica under the influence of heat in the presence of a flux form silicates with sodium potassium, and calcium, lead, etc., and the alkaline silicate then dissolves the remaining silicates. It is this solution that solidifies into glass on cooling. Glass may be divided into four general classes: plate, window, green bottle, and flint. Owing to manufacturing conditions, few makers follow the same formula, but the following table shows the general proportion by weight which sand bears to the other ingredients commonly used in certain types of American-made glass.[2]

General Proportions, by Weight, of Various Components of Glass.

Component.	Plate Glass.	Window Glass.	Green Bottle.	Lead Flint.	Lime Flint.
Sand (SiO_2)	100.00	100.00	100.00	100.00	100.00
Salt cake (Na_2SO_4)		42.00	38.00		
Soda ash (Na_2CO_3)	36.00				36.00
Limestone ($CaCO_3$)	24.00	40.00	34.00		
Carbon (C)	.75	6.00	5.00		
Arsenic (As_2O_3)	1.00	2.00		.15	.02
Slaked lime ($Ca(OH)_2$)					12.00
Potash (K_2CO_3)				34.00	
Red lead ($2PbO\text{-}PbO_2$)				48.00	
Niter ($NaNO_3$)				6.00	1.00
Manganese (MnO_2)				.06	6.66
Antimony (Sb)				.02	.23

REQUIREMENTS OF GLASS SAND.

"Sand is therefore the major constituent of glass, constituting from 52 to 65 per cent of the mass of the original mixture, or from 60 to 75 per cent of the finished product after melting has driven off carbon dioxide, sulphur dioxide, and other volatile materials. To the sand is due the absence of color (according to its purity), the transparency, brilliancy, and hardness of glass. In other words, the quality of the glass depends largely on the quality of the sand. For the finest flint ware, such as that used for optical and cut glass, "water whiteness,"

[1] From Advance Chapter of Mineral Resources of 1911.
[2] Data, except for lime flint, are according to Robert Linton's article on Glass, in Mineral Industry for 1899, vol. 8, 1900, pp. 244-245.

absolute transparency, great brilliance, and uniform density are required, and only the purest sand can be employed, since slight impurities, especially small quantities of iron, tend to destroy these effects. For plate and window glass, which are commonly pale green, absolute purity is not so essential, but generally the sand should not carry more than 0.2 per cent of the ferric oxide. Green and amber glass for bottles, jars, and rough structural work can be made from sand relatively high in impurities. An excess of the chief impurity, iron, is usually avoided in the quarries by a careful selection of the whitest sand, although the whitest sand is not invariably the purest. Repeated washing tends to remove the iron. Magnetic separators also have been resorted to, especially when the iron is present in the form of magnetite. Clay materials are objectionable because they cloud the glass. Washing helps to remove them, since they occur usually in a very finely divided state. Magnesia, which is more apt to be introduced into glass materials through limestone than through sand, is troublesome because it renders the batch less fusible. If the sand is derived from indurated sandstone, the latter should be friable or easily crushed. In examining sand in order to ascertain its value for glass making, inspection with a magnifying glass is the best preliminary test. The following points should be observed: The sand should be nearly white in color; it should be of medium fineness (passing a 20- to 50-mesh horizontal sieve); the grains should be uniform in size, even, and angular, or, less preferably, they may be rounded. A simple chemical test may be employed by heating the sand in a dilute acid. Effervescence indicates the presence of lime; loss of color shows the presence of clay impurities. Iron in the most minute quantity may be detected by dissolving sand in hydrofluoric acid and adding potassium ferrocyanide, which produces a blue precipitate if iron is present. Complete quantitative analyses, as well as a furnace test, should be made as a final determination of the character of a prospective glass sand. The impression has long prevailed, especially among writers on the subject of glass making, that round-grained sands are at a decided disadvantage in comparison with the sharp, angular variety. Practice seems to disagree with this idea, at least in the case of the Mississippi Valley plants, where smooth, rounded sand is successfully used for all ordinary varieties of glass and for some fine flint ware. As a rule, no very close check is kept on materials by manufacturers of the ordinary commercial grades of glass. Results are watched with care, however, and experience with certain materials usually determines their use or rejection. Sand uniformly finer than one-sixtieth inch is said to "burn out" in the batch and not to produce as much glass

per unit of weight as does coarser sand. In a mixture of coarse and fine sand the finer sand is liable to settle to the bottom of the batch, thus preventing an even mixture of the materials and producing in consequence a glass uneven in texture."

PRODUCTION.

The production of sand and gravel in North Carolina used for the various purposes mentioned above was valued in 1911 at $93,336 and in 1912 at $19,737. The greater production in 1911 was due to a large production by the Atlantic Coast Line Railway for ballasting purposes. This production of sand and gravel is obtained from: Anson, Buncombe, Cleveland, Columbus, Cumberland, Gaston, Guilford, Harnett, Halifax, Henderson, Iredell, Mecklenburg, Montgomery, Moore, Robeson, Wayne, and Wilkes counties.

The following table gives the production of sand and gravel in North Carolina from 1905 to 1912, inclusive:

Production of Sand and Gravel in North Carolina, 1905-1912.

Year.	Value.
1905	$ 547
1906	9,191
1907	2,191
1908	2,070
1909	13,358
1910	13,406
1911	93,336
1912	38,487

PRODUCERS.

The following were producers of sand and gravel during the past two years:

Atlantic Coast Line Railway Company, Wilmington, N. C.
Balfour Quarry Company, Asheville, N. C.
C. S. Fraley, Bessemer City, N. C.
Glasscock Stove and Manufacturing Company, Greensboro, N. C.
Cape Fear Gravel Company, Norfolk, Va.
J. C. Steele & Sons, Statesville, N. C.
Johnston, Potter & Peck, Charlotte, N. C.
Mecklenburg Iron Works, Charlotte, N. C.
Aberdeen and Asheboro Railway Company, Biscoe, N. C.
Dewey Bros., Inc., Goldsboro, N. C.
J. V. Wallace, North Wilkesboro, N. C.

SAND-LIME BRICK.

In the reports for 1905-1910 there were pretty complete descriptions of sand-lime brick and their manufacture. This industry has not thus far flourished in North Carolina. It began in 1904 and was maintained in a somewhat prosperous condition through 1908 with a production varying from $14,000 to $38,000 in value. In 1909-1910 there was a very small production of sand-lime brick reported, but in 1911-1912 no production was reported.

PRODUCTION.

The following table gives the production from 1904-1912, inclusive:

Production of Sand-lime Brick in North Carolina, 1904-1912.

Year.	Common Brick.		Front Brick.		Total Value.
	Number.	Value.	Number.	Value.	
1904	1,800,000	$ 17,500		$	$ 17,500
1905	3,185,000	20,953	660,000	8,150	29,103
1906	3,147,000	22,225	750,000	10,750	32,975
1907	4,068,000	29,458	755,000	9,350	38,808
1908	1,450,000	10,500	300,000	3,500	14,000
1909*					
1910*					
1911*					
1912*					

*Production given in General Mineral Table under "Miscellaneous," p. 16.

FELDSPAR AND KAOLIN.

A recent investigation has been made by Mr. A. S. Watts[1] of the U. S. Bureau of Mines on the feldspars and kaolins of the Southern Appalachian Region, which contains a description of the occurrence and value for pottery purposes of the feldspars of North Carolina, and there is given below that portion of the report which relates to North Carolina.

FELDSPAR AND KAOLIN DEPOSITS.

By A. S. Watts.

Feldspar is a mineral which quite readily alters, forming a new mineral known as kaolin, and the process of this alteration is termed "kaolinization." The process consists of the decomposition of the feldspar and the recombination of some of the decomposed products to form the kaolin. The process is outlined below:

[1]Bulletin No. 53, U. S. Bureau of Mines, Mineral Technology, 1, 1913.

KAOLINIZATION.

"The term kaolinization is used to signify the process of decomposition of feldspars and the recombination of some of the decomposition products to form kaolin. The process is as follows:

Kaolinization.

	By Molecules.				By Weight.			
Feldspar	1 K_2O	1 Al_2O_3	6 SiO_2		17 K_2O	18.4 Al_2O_3	64.6 SiO_2	
Loss by H_2O solution	1 K_2O				17 K_2O			
Insoluble decomposition products		1 Al_2O_3	6 SiO_2			18.4 Al_2O_3	64.6 SiO_2	
Kaolin		1 Al_2O_3	2 SiO_2	*2 H_2O		18.4 Al_2O_3	21.5 SiO_2	*6.44 H_2O
Free silica			4 SiO^2				43.1 SiO_2	

*Water of combination.

"We thus see that of 100 parts of potash feldspar decomposed, 17 parts of potash are lost by solution and 43 parts of silica and 46.44 parts of kaolin remain; the kaolin is made up of 40 parts obtained from the feldspar (18.4 of alumina and 21.6 of silica) plus 6.44 parts water of combination absorbed. The total of the insoluble products (plus the water of combination) is 89.44 per cent of the feldspar decomposed. A bed of residual kaolin (kaolinized feldspar) should therefore contain (minus the potash and plus the water of combination in the kaolin formed) 51.92 per cent kaolin and 48.08 per cent free silica.

"This is on the assumption that the deposit is pure feldspar, but such an assumption is rarely true. In the area investigated the feldspars of the pegmatites are mixed with varying amounts of quartz. Other minerals are also present in small quantities, so that to find a kaolinized dike averaging 40 per cent pure kaolin is exceptional.

"It rarely happens that the kaolin and quartz products of the feldspar disintegration are evenly distributed throughout the residual deposit. The tendency seems to be for the kaolin to filter down through the quartz particles until it has formed a compact mass where it packs together into a bed that may run 92 to 93 per cent kaolin. Below this bed in the decomposed dike lies another stratum of quartz sand which with depth becomes progressively richer in kaolin until another bed of nearly pure kaolin is encountered.

"The extent of this process of disintegration and concentration varies in different dikes and in different localities, but the process is more or less evident in every dike studied.

"As the extent to which kaolinization by weathering has progressed in the dikes examined varies inversely with the depth, it is not surprising to note that the plasticity of the kaolin decreases with the depth of a dike until the proportion of semikaolinized material becomes so great that deeper mining for kaolin is unpractical. This semikaolinized material, if devoid of plasticity, acts like feldspar or quartz sand in the washing process and may all be removed by the mica troughs and screens.

"The depth at which this nonplastic material becomes noticeable in the dikes studied can be roughly set down at 40 to 45 feet, although the richest and apparently most plastic kaolin is always found when the present water level is reached. It is doubtful if this kaolin is really more plastic than the rich pockets met at higher levels, but it appears so owing to the excess of water that it carries. In some dikes the kaolin content of a decomposed dike steadily increases until water level is reached, and in such cases the deposit at that point is very rich.

"The feldspar in the dikes is in all stages of decomposition, from fresh feldspar to perfect kaolin. The present topographic location seems to be no guide in determining the extent to which the kaolinization of a dike has progressed. Fresh feldspar and completely kaolinized feldspar lie almost side by side and at the same elevation. On Tremont Mountain, Macon County, N. C., fresh feldspar and kaolin deposits are only a few hundred feet apart at the same level. The two dikes are identical in structure, each having a vertical horse of pure quartz in the center, and narrow veins of mica-bearing pegmatite along the hanging and foot walls. At Penland, Mitchell County, N. C., a dike in an advanced state of kaolinization is being worked for kaolin, and 50 yards distant a dike containing fresh feldspar is being worked. In this case, however, the kaolin deposit is not well defined and appears to have been disturbed by a slide, whereas the fresh feldspar is in a well-defined dike. Near Jasper, Pickens County, Ga., a kaolinized dike follows the crest of a low ridge, while 100 yards distant and 50 feet lower is a dike with fresh feldspar.

"Many other similarly associated dikes of feldspar and kaolin are mentioned in the description of the mines and prospects investigated.

PROSPECTING AND SAMPLING.

PROSPECTING FOR FELDSPAR AND QUARTZ.

"Prospecting for feldspar and quartz is necessarily done either by open cuts or tunnels. The country rock is generally no more disintegrated than the pegmatite, so that the auger is useless. Wherever the

pegmatite is rich enough in feldspar to justify mining, there are likely to be outcropping bands of quartz in place by which the presence and the direction of the dike are indicated. The first task, therefore, if the overburden is light, is to dig a trench exposing the full width of the dike.

"The iron stains caused by infiltration from the overburden may extend several feet into the deposit and necessitate the removal of a considerable amount of the surface of the dike before satisfactory samples can be taken.

"In determining the extent of the dike it is necessary to run cuts across the strike at intervals. The surface of the dike should be removed at least until fresh feldspar is exposed and each of the various bands should be measured and sampled across its entire face.

"If these cuts are made at 50-foot intervals and the various bands occur in the same order and are approximately the same size there is little need of testing at shorter intervals, but if any irregularity occurs it is wise to reduce the distances between trenches to not more than 25 feet.

"The trenches can in most cases be cut by plow and the material removed by scraper, although some hand labor is always necessary.

"Where the overburden is so heavy as to render its removal impractical, the driving of a 'tunnel' adit or crosscut may be necessary. This work is not different from that of driving any rock-tunnel of the same size, although the tunnel should be driven as far as practical from the heavy flint band which is badly ruptured in order to eliminate the danger from working in broken ground. By clearing the face a cross section of the dike can be obtained and by running a 25- or 50-foot tunnel and then crosscutting, a second face on the same cross section can be exposed.

"It is also advisable wherever possible to crosscut the dike at two or more levels in order to ascertain whether the structure varies with depth. Care should be exercised in driving tunnels that enough slope is allowed for proper drainage and that sufficient headroom is provided for convenient operation. The quartz bands running with the feldspar may be prospected in the manner just described and in most cases the two can be conveniently worked together, the quartz being reached by crosscuts from the main entry.

SAMPLING OF FELDSPAR AND QUARTZ.

"The full face of the dike should be exposed and each band measured. The sample can be most satisfactorily obtained by using a sampling cloth of generous size and, with a geologist's edged hammer, or a chisel

and hammer, making a cut of uniform depth and width across the entire face. As is suggested in connection with the sampling of kaolin, the various bands should be sampled separately so that any undesirable material may be eliminated. For average samples of the entire deposit one has only to refer to the record of width of the various bands and to blend the separate samples proportionately.

"For chemical and physical tests it is necessary to reduce a portion of the samples to a fine powder. The sample taken should be reduced to one-half inch size, spread evenly on a smooth sampling cloth or a large smooth paper, thoroughly mixed, and then quartered; if necessary the quarter taken may be crushed to one-eighth-inch size, thoroughly mixed and requartered, the mixing and quartering being repeated until a sample of suitable size for fine pulverizing is obtained. This sample should be pulverized in a hard porcelain or agate mortar until all of it passes a 120-mesh sieve.

PROSPECTING FOR KAOLIN.

"Within the area studied very little prospecting has been done except the "ground-hog" mica mining, and this has resulted from exposure of mica-bearing ledges on the surface.

"Dikes are so irregular that only by the most thorough prospecting can the extent of a deposit be ascertained.

"The surface indications are mainly confined to scattered quartz bowlders except where a gully exposes kaolin or pegmatite in place. A typical example of a bowlder-strewn surface is shown in A, Plate XIV. The white quartz bowlders, which were once a band of the dike, have alone withstood disintegration and are scattered over the surface.

"Where such indications are found the prospector should bore with a standard wood auger welded to sectional steel pipe. If he finds kaolin, the boring should extend at least 30 feet into it. As a resistant flint band may be encountered at any time owing to nearly all dikes not being vertical, testing with the auger is often very unsatisfactory. The auger holes should be sunk at intervals of not more than 10 feet until the general direction of the dike is definitely determined and, if possible, its width and extent are ascertained. A great number of holes are certain to be sunk that cannot be completed owing to auger striking hard quartz rock or penetrating loose sand. It is practically impossible even by putting water into the hole to remove the borings from a sand bed.

"When the presence of a considerable deposit has been established, it will be found much more satisfactory and also more economical to open a tunnel or sink a shaft into the deposit than to investigate further by boring. Unless the deposit is to be worked at once, shaft sinking is not

A. Typical surface indications of a disintegrated Pegmatite Dike. The white bowlders are derived from a quartz band in the dike.

B. Open-cut mining for Feldspar.

recommended except where the deposit is a great distance from the face of the hill. A tunnel can be cut quickly and easily at 25 to 35 feet below the top of the deposit and if it has a very slight grade it will drain the deposit down to that level. Samples should be carefully taken completely across the dike by means of a crosscut to one side of the deposit and by horizontal borings opposite this crosscut. By frequent horizontal borings the exact width of the dike may be ascertained, and the grade of material in the different vertical bands be determined. By a little overhead stoping to make room for handling the auger, borings in the floor of the tunnel can be made to any desired depth.

"A prospecting tunnel should be not less than 6 feet high with an arched roof, but need not be more than 3 feet wide. If a flint horse is encountered it may be easily broken through or may be followed on either side, as it invariably runs parallel to the dike, although its face is often more or less irregular.

"Such a tunnel, if properly cut, will not cave for many years; several of the tunnels examined are still open and in good condition, though driven twenty years ago and not repaired since.

"The objections to shafts are the tendency to cave and to fill with débris, and the staining of the walls by surface waters. Furthermore, a shaft becomes a collecting point for subsurface water, the walls become soft, and it is practically impossible to do any sampling unless the water is removed by buckets, which is very expensive.

"In the region examined auger holes soon become choked, and it is often more economical to bore a new hole than to reopen an old one; hence boring does not provide any means of permanently opening koalin deposits for testing.

"It must be borne in mind that the dimensions of the bands in a face are no criterion of what may be expected even a few yards beyond, hence the extent of the bands throughout the area tested alone can be considered in any prospecting report. This statement applies to horizontal rather than vertical dimensions, although the latter are also subject to variation, especially those of the kaolin.

SAMPLING THE KAOLIN DEPOSIT.

"The method of taking the samples for test is of the utmost importance. Even after the deposit has been carefully proved throughout its length and depth, a lack of care in sampling may render the data obtained of little value.

"When samples are taken by boring from the surface the author has found it advisable to use a larger bit for boring through the overburden.

To prevent any particles of overburden falling in, the sides of the hole should be well packed with a smooth round pole or sapling before boring into the deposit begins.

"A careful record should be made of the appearance of each sample as it is removed from the auger and in case a sample looks notably different it should be kept separate. Not over 5 feet of borings should be sampled into one bag, as the mixing of large samples may lead to wrong conclusions. In vertical sampling the sampler should remember that he usually cuts the deposit obliquely and may strike a narrow band of undesirable material that could be removed in mining. The borings from such a band because of its loose texture and the tendency of the auger to tear off particles when raised and lowered may make the band seem thicker than it really is.

"A careful record should be kept of all samples, the point at which taken and the depth being noted. The importance of taking complete notes should be constantly borne in mind.

"In sampling a tunnel the problem of obtaining satisfactory samples is much simpler, but the tendency to collect false samples is even greater than in sampling by bore holes from the surface.

"Where a large area of material is exposed, the tendency is to go to that section which appears most promising and to take the samples there. The most satisfactory method of sampling a tunnel is to divide it into 5 or 10 foot sections and sample each separately. As the dike bands vary horizontally rather than vertically, it is always advisable to sample the crosscuts, and in sampling these, as in sampling auger holes, much care must be observed to prevent a narrow band of impure material from being given more importance than it deserves.

"First, clean the face exposed in one side of the crosscut with a shovel. Then sample each band separately across its full width. If stained material is encountered, its approximate extent can be determined and a sample preserved for test. In some dikes the kaolin shows peculiar variations in tint that cannot be detected after washing.

"The preservation of these samples separately is very important, since, as will be shown, different portions of the deposit may possess different physical properties, thus rendering a blending advantageous. Also it is possible, if desired, to blend the different samples in the same proportions in which they exist in the deposit, and thus obtain a sample representative of the entire deposit.

PROPERTIES OF FELDSPAR IN PORCELAIN MIXTURES.

"The rôle of feldspar in the porcelain mixture is that of a cementing material or solvent, its activity depending upon the temperature attained in the firing process. If the temperature only softens the feldspar the latter can do nothing more than bond the quartz and kaolin with which it is intimately mixed. If the feldspar is heated until it becomes fluid, it can take into solution part of the quartz and kaolin, and thus form a more or less homogeneous mass. Impurities in the feldspar may not appear greatly injurious in their action when the feldspar is tested alone, but may materially affect the speed of reaction and other properties of the feldspar when used in porcelain mixtures.

"The action of a feldspar in porcelain mixtures is the only safe and proper basis for judging its industrial value. Experience has proved that it is not essential that the proportions of a porcelain mixture for testing be industrially correct, but rather that those proportions be selected which will cause the ingredients to display most pronouncedly any faults that they possess. Thus an excess of feldspar will increase the tendency to warp and also to produce bad colors. For practical test, the following proportions have been found most satisfactory: Feldspar, 20 per cent; kaolin, 50 per cent; and quartz, 30 per cent, mixed with 50 grams of water.

SEMIKAOLINIZED FELDSPAR.

"The name 'semikaolinized feldspar' is used to designate all those deposits of material that have so altered that they can no longer be classified as fresh feldspar, but on the other hand have developed no plasticity and hence cannot be classified as kaolin.

"The location of the deposits of such material is divided into two classes, (*a*) isolated bands, (*b*) semikaolinized dikes.

(*a*) In kaolinized dikes containing many bands of widely differing material there are always found one or more bands that have withstood weathering and that produce no kaolin. Such bands are invariably found to consist of semikaolinized feldspar. These bands are lenticular and the presence of a broad exposure of such material is no indication that all the surface of the dike will consist of this material.

"In dikes containing semikaolinized material, the mining of the kaolin necessitates the removal of these hard bands and heretofore they have been thrown aside as refuse together with quartz bowlders and other undesirable foreign material.

(*b*) In dikes that are apparently completely kaolinized on the surface, mining to about 100 feet exposes less altered material, and the degree of

kaolinization decreases with depth until fresh feldspar is reached. Thus in such dikes the semikaolinized feldspar lies below the kaolin and above the fresh feldspar. Although its alkali content increases downward, the variation is generally not so abrupt as to cause difficulty, and with care in mining and with proper mixing of the mined material a uniform product should be easily produced.

"This semikaolinized feldspar is peculiar in that in 16 such deposits sampled no semikaolinized soda feldspar was found, every deposit being potash feldspar with a maximum soda (Na_2O) content of 1.11 per cent. Furthermore, the potash (K_2O) content is higher than in most feldspar, being 14.40 per cent in one specimen, and the alumina (Al_2O_3) content is invariably higher than is theoretically required either in the potash or soda feldspar.

"The foregoing observations seem to justify the conclusion that these semikaolinized feldspars found in lenses or bands in an otherwise kaolinized dike represent a material that contains more potash and alumina than the associated bands and, being more resistant to weathering, has remained only slightly altered while the remainder of the dike has completely broken down.

"The presence of an excess of Al_2O_3 and also the presence of combined water indicates the progress of weathering and doubtless the giving up of some alkali. The fact that no fresh feldspar that carries more potash than these semikaolinized feldspars is found in this district would indicate that weathering has removed the Na_2O, if any alkali has been removed. This removal of the soda portion of the feldspar before that of the potash portion might be expected from the weaker resistance to weathering of soda feldspars.

"The semikaolinized material below the upper kaolinized part of the dikes also shows this high potash content and low soda content. Here is additional proof that weathering has affected the soda-bearing material first.

"Examination of the kaolin above the semikaolinized part of a deposit fails to disclose more than a small percentage of Na_2O, the K_2O content always being in excess, hence the Na_2O, if leached out, must have been completely removed from the dike.

"The potash content, in the samples taken, varies from 1.7 to 14.4 per cent K_2O, the amount of combined water varying inversely as the alkali content. As the samples were taken to represent the average composition of the portion of the dike sampled, no information as to the rate of alteration can be obtained from their study, but the data at hand indicate that in deposits containing 50 per cent or more of the original alkali

content the proportion of combined water present may be taken as a fair criterion of the proportion of alkali removed.

"The alkali content would be expected to control the deformation temperature provided the other ingredients remain reasonably constant. Although a small change in alkali content seemingly affects the deformation temperature only slightly, the combined water content is a

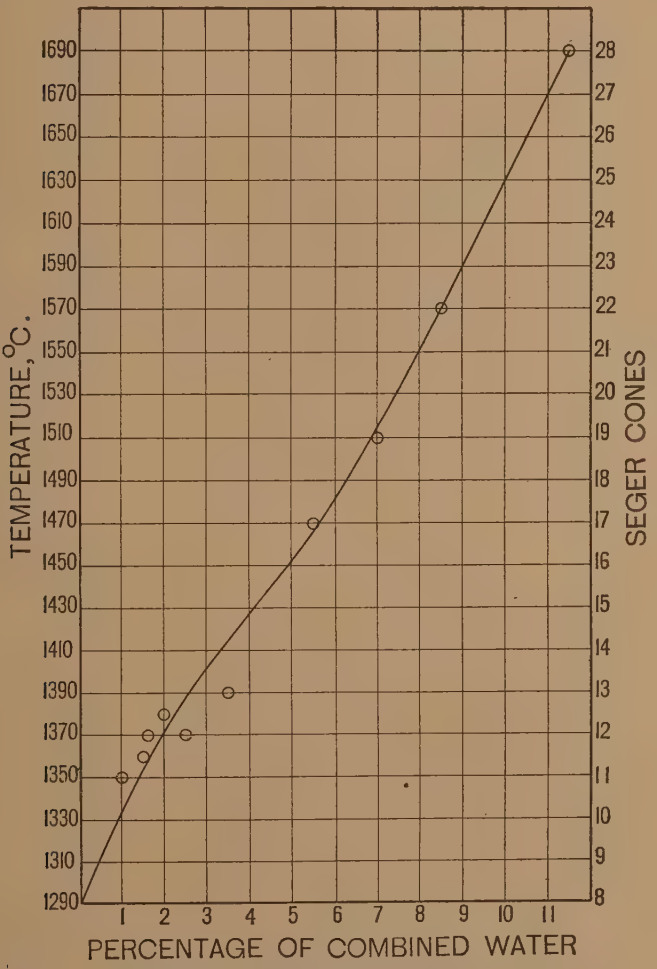


FIG. 9. The deformation temperature of semikaolinized feldspar platted against the combined water content.

reliable indicator of the deformation point of the semikaolinized feldspar. Thus it appears that the change in deformation temperature is due not only to the proportion of alkali and other elements present, but also to the mineral form in which these elements exist. Figure 9 indicates the consistent increase in deformation temperature with increased combined-water content. In this figure are plotted data from 10 of the best exposed deposits coming under this classification.

"The lack of better agreement is doubtless due to the fact that when a dike is exposed to the elements for any time the alkalies leach from its surface and the taking of representative samples is rendered difficult, even though the surface material be removed for several feet.

"A peculiarity of all these semikaolinized feldspars is their gradual deformation. The softest of the specimens tested were vitreous and highly translucent for 50° C. before they deformed. Some of the harder specimens were vitreous for almost 100 degrees.

"Another physical property to be considered in connection with a study of these materials is shrinkage in firing. When fired at 1,330° C. the specimens that are only slightly kaolinized shrink 15 per cent. With greater kaolinite content the shrinkage decreases, until in specimens containing 60 per cent kaolinite the shrinkage is only 10.75 per cent. With increased kaolinite content the shrinkage increases again, until in specimens showing a content of 14 per cent combined water but no plasticity the shrinkage ranges from 12.5 to 15.25 per cent.

"This peculiarity in shrinkage is explained as follows: In the slightly kaolinized specimens the excessive shrinkage results from vitrification, whereas in the specimens nearing complete kaolinization the shrinkage is due to the grains being very fine.

"The deposits containing little or no alkali, but having no plasticity and forming the refractory end of this series, can possess little or no interest for the ceramist owing to their great shrinkage.

"For the deposits containing one-half or more of their original alkali content, a ready market should be found in the pottery industry. The majority of these semikaolinized feldspars may be crumbled in the fingers, and at best a very light grinding would suffice to reduce the material to an impalpable powder. Thus the cost of grinding would be only a small proportion of the ordinary cost. An additional advantage of these materials is their pure color, which should make them especially suitable for raising the quality of cheaper soda feldspars that are too much colored to be easily marketable.

"These semikaolinized feldspars are merely mixtures of the materials ordinarily employed in pottery bodies, and in some instances the plas-

ticity of the fully developed kaolin is the only essential lacking in order to produce a perfect porcelain.

"For example, a semikaolinized feldspar has the following chemical composition:

Composition of a semikaolinized feldspar.

H_2O	2.78
SiO_2	64.59
Al_2O_3	20.80
K_2O	11.83
	100.00

"Recalculation to mineral components gives the following composition by weight:

Mineral components of a semikaolinized feldspar.

Component.	K_2O.	Al_2O_3.	SiO_2.	H_2O.	Percentage of Total.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	
Analysis	11.83	20.80	64.59	2.78	100
Feldspar	11.83	12.84	45.33		70
		7.96	19.26	2.78	
Kaolinite		7.96	9.26	2.78	20
Quartz			10.00		10

"Thus it is apparent that this material, which has a chemical composition unlike any regularly employed feldspar, is really merely a mixture of 70 parts microcline feldspar, 20 parts kaolinite, and 10 parts quartz, or flint. In fact, the production of a feldspar free from impurity or associated minerals is very difficult and expensive, and very little feldspar is sold that does not contain an appreciable amount of free quartz; hence the kaolinite component is the only new factor introduced.

SUBSTITUTION OF SEMIKAOLINIZED FELDSPARS FOR FELDSPARS.

"Although the value of semikaolinized feldspar, as a substitute for feldspar in pottery, has never been exploited, it should be one of the most valuable products of these dikes. It contains practically pure potash feldspar, and if the small amount of kaolin and free silica present is taken into account in the compounding of the body it can be readily seen that a porcelain of longer heat range could be produced than is

possible where the ordinary mixed potash and soda feldspar of commerce is used. The color of these semikaolinized feldspars is generally superior to the feldspars of commerce.

"For example, let us consider a porcelain of the following composition by weight:

Feldspar	16
Kaolin	45
Flint	39
	100

If a semikaolinized feldspar of the composition

Feldspar	70
Kaolin	20
Free silica or flint	10
	100

is used, the 16 per cent of feldspar in the porcelain is to be supplied by 70 per cent of the semikaolinized feldspar, the kaolin thus introduced being $^{20}/_{70}$ of 16 or 4.57 per cent and the flint $^{10}/_{70}$ of 16 or 2.29 per cent. The total semikaolinized feldspar being thus 16+4.57+2.29=22.86 per cent semikaolinized feldspar. The 45 per cent of kaolin in the body composition is reduced thus 4.57 per cent, which leaves 40.43 per cent to be introduced as pure kaolin. The flint or free silica in the body composition is 39 per cent, but 2.29 per cent is introduced in the semikaolinized feldspar, hence there remains to be introduced as flint 36.71 per cent. The mixture for the porcelain mentioned above will thus be made up as follows, by weight:

Semikaolinized feldspar	22.86
Kaolin	40.43
Flint	36.71
	100.00

"This simple recalculation shows that these semikaolinized feldspars may be made a valuable addition to American ceramic materials. It must be borne in mind that the feldspar thus introduced is potash feldspar and it must replace potash feldspar only. In case the feldspar to be replaced is a mixed potash and soda feldspar, this semikaolinized feldspar should be used to replace the potash feldspar only and soda feldspar should be used to replace the soda feldspar. This replacement can be made with considerable saving, because soda feldspar has a lower market value than potash feldspar.

"The use of this semikaolinized material would require the making of careful and thorough tests before its introduction, but to the technically trained man the substitution of this material for commercial feldspar is a simple problem, and the advantages to be gained by the improvement in color and increased heat range would more than repay any inconvenience caused.

"The tests for vitrification range, color, shrinkage, and translucency, when this material is substituted for a feldspar, should be made in the same manner as in testing a feldspar.

"When it is hoped to substitute some of the more refractory semikaolinized material, only the least plastic kaolin should be replaced, and great caution should be taken lest the mixture be made too friable and weak after drying.

"Another market for this material, which contains a considerable amount of potash, may arise if potash is ever commercially extracted from feldspar.

KAOLINS.

"Kaolin, or white-burning residual clay, varies more or less in its physical and chemical properties, depending on the rock of which it was a disintegration product. When freed from the other residual material with which it is almost invariably mixed, its chemical composition approaches very closely that of the mineral kaolinite.

"Kaolinite has the formula $Al_2O_3.2SiO_2.2H_2O$, which, expressed in percentages, is as follows:

Composition of kaolinite.

SiO_2	46.3
Al_2O_3	39.8
H_2O	13.9
Specific gravity, 2.6.	100.0

"An ultimate chemical analysis, by which the percentage of each component of the kaolin is determined, is valuable as indicating the impurities present and the proportions in which the various components are present, but without additional data in regard to the physical properties and the mineral composition of the kaolin one can form little idea from such an analysis of the actual commercial value of the material. The following analyses show how similar may be the chemical composition of a kaolin, a fire clay, and a ball clay.

Analyses of North Carolina kaolin, fire clay, and ball clay.

(Analyses of kaolin and fire clay by Ries. Analysis of ball clay by Edward Orton.)

Constituent.	North Carolina Kaolin.	Fire Clay.	Ball Clay.
SiO_2	45.40	45.29	48.94
Al_2O_3	37.34	40.36	36.69
Fe_2O_3	1.92	.51	.35
CaO	.44	.037	.47
MgO	.20	.015	.71
Alkalies	.52	.136	1.28
Water of combination	13.96	13.608	12.14
Totals	99.78	99.956	100.58

The physical tests show the following results:

Physical tests of North Carolina kaolin, fire clay, and ball clay.

Material	North Carolina Kaolin.	Fire Clay.	Ball Clay.
	Per Cent.	*Per Cent.*	*Per Cent.*
Shrinkage	Air 4	Air 6	Air 8
	Fire 8.5	Fire 3	Fire 11
	Total 12.5	Total 9	Total 19
Color	White.	Gray.	Cream.

"It is generally understood that the content of iron oxide is a gauge of the color of the burned clay, but here is a kaolin with 1.92 per cent oxide of iron burning a pure white, although a fire clay with 0.51 per cent oxide of iron burns gray and a ball clay with 0.35 per cent oxide of iron burns cream.

"The shrinkage also shows the same great variation, the ball clay having more than twice the shrinkage of the fire clay, and the kaolin falling between them. The tensile strength of these clays varies as greatly as their other properties. In the air-dry state the fire clay will hardly hold itself together and is generally worked with some more plastic clay as a bond. The kaolin may hold 40 to 45 per cent of nonplastic material together, but even when pure it has too little bonding strength and must be handled carefully. The ball clay is remarkably tough and will carry 70 to 80 per cent nonplastic material and produce a strong air-dry product.

"From the foregoing statement it is apparent that for the comparison of clays from widely differing sources the chemical analysis has only a

limited value. However, where the clays being compared are of similar origin the chemical analysis is of great value and may furnish a means of explaining otherwise unaccountable irregularities. Manifestly the chemical analysis is valuable only when the samples have been taken so as to fairly represent the deposit.

"When, as in the present case, the material under investigation is not completely altered, the rational analysis is a valuable aid. Pure kaolin is known to be decomposed by sulphuric acid, but feldspar and quartz are only slightly, if at all, attacked in a carefully made rational analysis. This difference furnishes a means of dividing the feldspathic material and quartz from the kaolin. Mica, if present, causes confusion, because it is decomposed by sulphuric acid and hence is taken out with the kaolin.

MINING AND REFINING OF FELDSPAR AND KAOLIN.

FELDSPAR.

MINING BY OPEN-CUT.

"The mining of feldspar by open-cut is the simplest form of quarrying. The dike is exposed by removing the overburden along a slope and the material is broken down by wedging where practical, but usually by drilling and then blasting with dynamite. The different bands of the dike are generally well defined, and hence there is no difficulty in selecting material and the elimination of any undesirable bands is left until the material is sorted for shipment. The wall rock of the fresh feldspar dike is generally solid and no danger of slides exists except where walls are loosened by blasting. The open-cut is generally kept level to the face of the hill to facilitate drainage, even though the quarry products are necessarily removed from a higher point. When the quarry extends below the outlet level, pumps are used to handle the water. No difficulty is encountered, since the water is allowed to drain into a central pool, where it settles before it is pumped. (See Pl. XV A and B.)

"The products of the dike are removed by wheelbarrow or by horse and cart to a point outside the quarry where sorting and cobbing are carried on.

TUNNELING AND STOPING.

"Where feldspar alone is the product of a dike, tunneling and stoping have never been used within the district under investigation, but where mica is found in paying quantity in the dike, this method of mining is not uncommon. The practice is to run a drift or tunnel into the dike at as low a level as convenient. This drift is continued along the dike

until the latter pinches out or the mica becomes too poor and scarce for mining. A vertical cut is then made just inside of the point where the tunnel cuts the dike. This is sometimes carried up for about 12 feet in order to give two benches for working, although ordinary practice in this district is not to work more than 6 feet high at a time. This bench is cut out directly above the old tunnel and when the material is all removed another bench is cut above. In order to facilitate mining, it is customary to build 'lofts' of rough timbers above two or three benches and upon them to build platforms for reaching the dike material. Mining is done almost exclusively by drilling and blasting and only the valuable material is removed from the mines, the refuse being dumped into the worked-out area below or heaped in abandoned 'lofts.'

"By thus working from below, the maximum efficiency of the explosives is obtained and the cost of mining is kept low. The drainage of the mine is natural, since the entrance tunnel is the lowest point opened. Where the feldspar is removed from such workings an ordinary mine car is employed, running on a track to the point where stoping begins. The material is generally dumped from above into a hopper built at this point.

REFINING.

"Where the dike contains an excessive proportion of quartz or when the feldspar mined must be of extra quality, the dike product is all hand sorted as cobbed. In cobbing the feldspar is cleaned of all quartz and other associated minerals by means of light hammers and the pure feldspar in irregular lumps is ready for crushing and pulverizing.

CRUSHING AND PULVERIZING.

"Crushing and pulverizing is a simple process. If the feldspar is slightly altered it is occasionally calcined to remove the combined water, but ordinarily it is broken with sledges or with a jaw crusher to about 2-inch sizes and fed into a 'chaser' mill. This mill consists of two buhrstone wheels 3 to 5 feet in diameter and about 1 foot thick, which are attached to the ends of a horizontal axle that is pivoted in the center. The wheels travel around on a buhrstone bed and the feldspar is crushed between the bed and the wheels. The crushed material is screened and the coarse material returned to the chaser mill, while the fine material is fed to ball mills. The latter are steel-barrel tumbler mills 6 to 7 feet long and of about the same diameter. They are lined with hard wood or silica blocks and are charged with French flint pebbles 2 to 3 inches

A. Open-cut mining for Mica in a pegmatite dike, both walls being solid rock.

B. Open-cut mining for Kaolin. This dike contains no quartz bands, differing therein from most dikes in this district.

in diameter. The revolving of the mill causes the pebbles to roll or slide, thus pulverizing the feldspar.

"The pulverized feldspar is rarely screened, but the degree of fineness is determined by testing small samples of the material, and the length of the grinding period is depended on to give the desired pulverization. If the pegmatite carries mica the pulverized material should be screened through a fine sieve to remove any unpulverized material.

KAOLINS.

REMOVAL OF OVERBURDEN.

"Removal of the overburden is one of the most important and at the same time one of the most neglected details of kaolin mining in the Southern Appalachian region. The method commonly used is to remove just enough overburden to expose the dike and to proceed at once to mine the kaolin. No provision is made for removing surface water during rains, and the invariable result is that more or less overburden is washed into the excavation, staining the walls and otherwise reducing the value of the kaolin in the upper part of the deposit. As the dikes in this region generally dip from 70 to 80 degrees from the horizontal and often toward higher ground, due provision must be made in removing overburden if the upper portion of the dike is to be mined by open-cut, so that the walls need not be too nearly vertical or undercutting become necessary in order to mine all the dike material.

"The nature of the overburden influences greatly its tendency to slide and wash, but throughout the region it has been found advisable to slope all overburden walls not less than 30 degrees from the vertical. A level space equal to at least one-half the thickness of the overburden should be maintained around shafts as a protection against slides. This space should never be less than 10 feet wide in order to provide for the safe and economical handling of timbering material for the shafts and for dumping buckets of mine products well away from the shaft mouth.

"The method of drainage found most efficient and economical is an ordinary ditch dug as close to the foot of the overburden walls as safety permits. This ditch should be at least 1 foot deep. It should be cut starting in a V above the last-opened shaft and follow the two walls to a point far enough beyond the operating shafts to insure the flow of surface water into a natural drainage way without soaking or running into a refilled shaft and thence into the part of the dike being worked. Much of the present trouble from water in shaft mining could be eliminated by providing and maintaining proper surface drainage. In removing

overburden, it is never advisable to remove material much below the top of the dike, even though the material be much stained, because the dike material is loose and will allow surface water to seep down from the drainage ditches. Where the overburden is very porous it may prove advisable to place wooden troughs in the drainage ditches and to fill in closely on the bank side to insure the surface water running into the trough.

MINING KAOLINS FROM DIKES.

"In the region studied kaolin is mined by two methods; namely, (*a*) open-cut and (*b*) shaft mining.

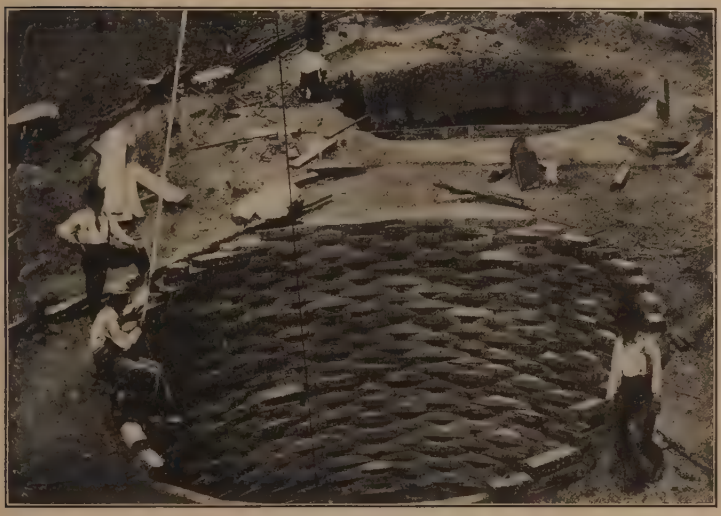
"In most cases the most economical results are obtained by combining the two methods, mining by open-cut for 20 to 30 feet next to the surface and by shaft below.

KAOLIN MINING BY OPEN-CUT.

"Where the inclosing walls are solid and the dike is nearly vertical, it is sometimes practical to mine the entire deposit by open-cut, especially if the overburden is thin and the deposit follows the face of a hill. The kaolin can thus be worked in benches and handled by carts with much more economy than by shaft mining. (See *B* XV.) Removal of overburden well beyond the area of operation and careful sloping of the walls of the cut will leave little danger from slides. It must be borne in mind that in such an operation the dike is attacked from the side and not across the face, and in order to obtain a uniform product every bench must be worked across its entire width at the same time.

"A more economical method of open-cut mining and one that is more certain to bring satisfactory results is to remove the wall rock on the lower side and thus expose the dike from the top to the lowest workable level. The dike is then cut through its entire width from top to bottom and benching proceeds on the two sides of this cut or, if advisable, on one side only. (See *A* Pl. XVI.) The drawback to this method is the high cost of exposing the dike from top to bottom in case the depth of mining reaches or exceeds 80 feet and the slope of the hill does not exceed 45 degrees. Many dikes are only 10 to 12 feet wide, so that the expense of removing the great quantities of wall rock in order to reach the kaolin becomes too great in proportion to the value of the product. Moreover some expense will also be incurred in open-cutting by reason of the necessity of sloping the back of the cut after the dike has been removed in order to prevent slides. The cost of removing the wall rock and of sloping the wall of the uphill side of the cut must be placed

A. Open-cut mining for Kaolin, showing bench mining and the dump-car system.



B. Shaft on hillside for mining Kaolin. The cribbing is higher on one side than on the other, thus exposing some timber ends.

against the cost of timber and timbering in shafts and the other items incident to shaft mining in considering the mining methods to be adopted at a dike.

"Mining by open-cut demands the removal of much more associated material than does shaft mining and is to be considered when a sufficient cash outlay is possible to provide the necessary equipment for the economical removal and transport of the refuse.

KAOLIN MINING BY SHAFT.

"Where the shaft method alone is used the only surface preparation necessary is provision for diverting surface water from the shafts. At many mines no overburden is removed, although at some the removal of part of the overburden is advisable in order to obtain a level area about the shaft mouth. The shafts in this region vary from 14 to 20 feet in diameter and from 40 to 110 feet in depth.

"The proper place for a shaft in a dike is a matter to be decided by the operator, but since the majority of the dikes dip 70 to 80 degrees and are only 10 to 20 feet wide, the general practice is to start the shaft in the hanging wall adjacent to the dike, so that the shaft cuts the dike on the hanging-wall side 2 or 3 feet below the surface, and on the foot-wall side from 50 to 75 feet below the surface according to the dip of the dike. Such procedure often necessitates the removal and handling of an amount of waste equal to or greater than the amount of dike material handled, but sinking and timbering a vertical shaft is so much simpler than sinking and timbering a slope that the operators throughout this district employ the shaft system exclusively. The dike material and the disintegrated gneiss that form the walls are both friable, so that timbering has to be placed as rapidly as the shaft is sunk.

"Sinking is done in the following manner: The shaft is sunk 4 feet, carefully trimmed to form a circle of the desired diameter, and timbering, which is really the most important part of the process, is begun. (See Pl. XVII A and B.) The timbers are of yellow pine or oak; they are 4 by 6 inches and generally 30 inches long, and are beveled on the ends to form key blocks. The timbers are placed beginning at the bottom of the 4-foot hole, and the joints are staggered as in bricklaying, thus forming a solid structure. (See *B* Pl. XVI.) Every fourth ring of timbers is spiked to the next lower ring in order to prevent any tendency to twist. When the timbers of the first level are in place, the shaft is dug 4 feet deeper, the timbering in place being supported by the material immediately below it, which is left in place until all other material has been

removed. This material is next removed and the timbering is supported temporarily by short props while the next set of timbers is placed.

"In placing these key blocks the final block completing a circle is put in by digging away the rock wall for a few inches, thus permitting the key to be placed from behind. The opening behind this block is then filled with waste and packed to prevent the block from kicking out. When the timbering has reached the bottom ring of the set above such packing is impossible, hence the final key block for the top ring of each set is cut 4 inches short, and after being placed, a short piece of 4-inch by 4-inch timber is driven into the opening left and is spiked tight. Sinking then proceeds as before. Each 4-foot slice of timbering always being placed as soon as the material from a level is removed.

"Owing to the danger of contamination by contact with the iron-stained material constituting the walls of the dikes, the removal of the kaolin should not proceed simultaneously with the removal of wall rock. The kaolin in a given level should be carefully removed and sent to the surface before the wall rock of that level is disturbed. This is not the practice in all mines, but is followed in most shaft mines.

"Where a dike incloses small lenses of waste material these should not be disturbed while kaolin is being mined, but should be taken out separately, as they generally contain much iron oxide, and a large amount of valuable kaolin may be injured by mixture with a little of the waste. Different buckets are generally used for handling kaolin and waste.

"One of the greatest difficulties in shaft mining is the removal of the quartz lenses that are sometimes found along the middle of a dike and which must be removed from within the shaft area. The use of explosives is unsatisfactory, because the quartz is more or less fractured, making the successful placing of a shot difficult. Breaking the quartz by sledge is slow and expensive, but has been found the safest and most economical method.

"When a shaft has reached the lowest level at which the dike yields kaolin in commercial quantities, robbing and filling begin. Short tunnels are run into the dike from the bottom of the shaft. When the valuable material has been mined by these tunnels as far as is considered safe without timbering, the pillars between the tunnels are carefully removed and the area which has been emptied of kaolin, both within and without the shaft, is filled with waste from adjacent shafts or with that which was stored on the surface when the shaft was sunk.

"As soon as a level has been thus robbed and filled, the timbering from the level next above is removed and that level is robbed and filled in the

A. Shaft mining for Kaolin. The flume for crude Kaolin is in the background.

B. Buckets used in raising material in shaft mining. The one on the right is for hoisting water.

same manner. The operation is continued level by level until the surface is reached. In this way every pound of kaolin is removed, and since the shaft timbers are recovered the cost of mining by this process is reduced to the minimum.

"For hoisting at shafts ordinary derricks are used throughout the region. Masts and booms are made from native timber, with the ends banded to prevent splitting.

"The type of bucket used holds about 500 pounds of dike material and is made from an oil barrel by cutting off the upper third. For hoisting water a whole oil barrel is used. A substantial wrought-iron hoop is placed about the bulge; a broad wrought-iron band, which passes under the bottom, is fastened to this hoop, and at these joints the handle of the bucket is connected. (See A and B, Pl. XVII.) To hold the bucket upright a heavy iron peg is attached to its side and extends above its rim. A heavy wrought-iron ring that encircles the handle of the bucket drops over this peg. The bucket is dumped by lifting this ring. The center of gravity of the bucket is so near the points where the handles are attached that the bucket dumps easily.

"The drum hoists are exclusively used at shafts. In some cases horse power is used, but steam-driven hoists are used at the majority of mines. At one mine electricity has been used for operating hoists, and has proved very satisfactory.

"Masts and booms of native timber are generally employed, and cables are of 5/8-inch stranded steel. Guys are generally of 3/8-inch stranded steel.

COMBINATION OF OPEN-CUT AND SHAFT MINING.

"Many dikes are too narrow to justify mining by open-cut. Moreover, the necessity of removing the overburden by an uphill or very long haul, as well as special conditions, may make mining exclusively by open-cut unpractical. The manner of mining must be determined for each deposit, regard being given existing conditions. Even though the entire dike cannot with economy be mined by open-cut, the upper portion for a depth of 30 to 40 feet may be mined by open-cut with far less expense than by shaft. When an open-cut is not more than 30 feet deep, sloping the walls is not expensive, and the overburden and waste removed will generally suffice to fill the shafts sunk into the lower portions of the dike. The practice is to remove overburden before shaft sinking only when the material removed can be utilized for filling a shaft from which all valuable material has been mined.

"Working the upper part of a deposit by open-cut also reduces the cost of shafting, because it exposes the dike and shows its width, thus insuring the shaft being sunk at the most advantageous point. (See *A* and *B*, Pl. XVIII and Pl. XIX.)

REMOVAL OF WATER FROM KAOLIN MINES.

"One of the most expensive items that the miner of kaolin in this region has to consider is the removal of water from the workings. The dikes are generally free from water to a depth of about 40 feet, but below this depth the seepage of water from the walls and from the dike itself often increases to an actual flow, and in many cases the inrush of water has driven the miners from the workings and stopped mining. In the earlier operations for mica it was customary to sink shafts to as near the water level as was considered safe, and drift along this level until a flow of water was encountered, then the shaft was abandoned and a new one sunk at no great distance. The mica found in the vicinity of the water is claimed to be especially free from faults and of the finest color.

"In kaolin mining the same in general is true. The finest quality of kaolin is generally found in the area between the level at which the first water is encountered and the level at which the flow becomes a menace to mining. Within the region studied the refilling of shafts on account of an excessive flow of water has resulted in leaving behind enormous amounts of kaolin of the highest grade. The remining of this abandoned material can be accomplished only at great expense, since the shafts are filled with refuse which must be removed before the abandoned material can be reached. The cost of such an operation would be prohibitive.

"Only the simplest methods have been used to remove water from kaolin mines, the uniform practice being to bail the water into barrels and hoist it to the surface. This practice requires no great outlay for special machinery, but delays the other mining operations and thus reduces the daily output of the shaft, which results in increasing the cost per ton of material produced. Moreover, the seepage of water into the shaft from all directions loosens the ground and increases its tendency to cave and slip.

"The use of pumps for handling water has met with little success, because the deposits contain much exceedingly fine sand which is carried in suspension by the water and cuts out the valves of pumps very rapidly. The height to which the water must be elevated varies from 50 to 120 feet, which precludes the employment of suction pumps or steam siphons.

A. Open-cut mining for Kaolin, showing irregular surface of deposit.

B. Typical gravity tramway.

Shaft mining after the open-cutting.

The running of tunnels at or below the level where water is encountered is the natural method of draining workings, but it has been tried at only one mine in the district and there was only a partial success, because although the deposit covered many acres of land the drainage tunnel was run into the deposit at only one point and no branch tunnels were run to assist in draining the more distant parts of the deposit. The tunnel, however, removed the greater proportion of the water, so that by occasional bailing mining could be carried on without great annoyance. At a mine in a similar dike outside this region the dike has been cut by numerous tunnels, all of which drain to a central sump or cistern, and the water is removed by pumps provided with filters for excluding sand. The mine is thus kept dry and mining is greatly facilitated.

"The situation of a majority of these dikes is ideal for drainage from below. Most of them lie well above the present water courses and most of the hills slope so abruptly that few tunnels would have to be driven more than 100 yards before reaching dike material. After reaching the dike, the cost of running the drainage tunnel would be little, if any, more than the cost of mining the kaolin in other parts of the dike. To insure the maintenance of an open drainage way, timbering would be advisable. The tunnel should be continued well into the dike and a number of branch tunnels should be run to the extreme limits of the deposit. The capacity some deposits have for holding water indicates that the complete drainage of a dike by tunnels cannot be accomplished in a few days, but a number of weeks or even months may be required. The cutting of the drainage tunnel should therefore be started as soon as possible after the trend and general extent of the deposit are determined. When such a tunnel is run below the level at which kaolinization is complete, it may be advisable to place a shot of dynamite in the ends of each crosscut tunnel and thus rupture the formation, permitting the water more easily to drain away.

CONVEYING THE CRUDE KAOLIN TO THE WASHING PLANT.

"The method of conveying the crude kaolin to the washing plant is of necessity influenced by the situation of the mines and the washing plant. At every mine except one studied in this region the mouth of the shaft or the floor of the open-cut is well above the washing plant.

"The method generally used is by flume, a stream of water being diverted into a V or U shaped trough (see Pl. XX), into which the crude kaolin is shoveled. In most cases the flume is carried into the mine, so that the crude kaolin on removal from the shaft or bench may be shoveled directly into the flume and a second handling is unnecessary.

In some cases, however, the flume is carried only to a point below the mine and the crude kaolin must be conveyed from the mine to the head of the flume. For this purpose a tramcar system has been used at two mines and is reported satisfactory. At one mine the tramcar system is supplemented by a gravity incline with cars. (See *B* Pl. XVIII.)

"In constructing a flume for transporting crude kaolin, caution must be exercised to avoid abrupt turns and drops in order to prevent the small blocks of mica, which exist everywhere in kaolinized dikes, from being broken into thin sheets and flakes by the battering they would receive. If the small blocks of mica are not broken they are readily removed with the coarse material by the sand wheels. The chief advantages of transportation by flume are that it is economical and coarse lumps of kaolin are disintegrated before they reach the washer. (See Pl. XX.)

REFINING THE KAOLIN.

CLAY WASHERS.

"The first step in refining the crude kaolin is accomplished by the washer. This is really a disintegrator, since its chief service is so to agitate the kaolin-bearing material that the kaolin may be separated from the quartz and other waste materials. A washer, shown in Fig. 10, p. 207, consists of a rectangular box measuring approximately 3 by 3 by 10 feet. Lengthwise through this box passes a shaft, to which are attached a number of arms that extend almost to the sides of the tank. The shaft is belt-driven by a pulley attached at the intake end of the washer, and revolves at about 200 revolutions per minute. Washers are generally operated in batteries of two, the material to be disintegrated passing directly out of one into the other.

SAND WHEELS.

"From the washers the crude kaolin passes to the sand wheels. Each wheel revolves in a narrow tank about 10 feet long and 6 feet high. To the spokes of the wheel are attached cast-iron scoops, each having a sloping end. As the wheel revolves, charges of coarse material not disintegrated by the washer are scooped up from the bottom of the tank. Figure 11 shows perspective of sand wheel and appurtenances. The kaolin mixed with this waste material drains away as a scoop rises, and when the scoop reaches the highest point of its circuit the coarse material slides out, is diverted by the sloping end in the scoop, and falls outside the tank. The kaolin and any other very fine material pass directly through the sand wheel and into the sand trough. In the Southern Ap-

Plant for washing Kaolin; (*a*) flume; (*b*) mica troughs; (*c*) drying shed.

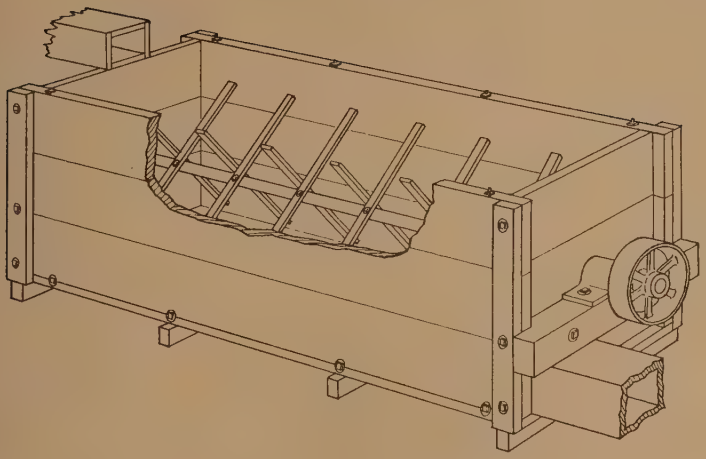


FIG. 10. Clay washer for kaolin.

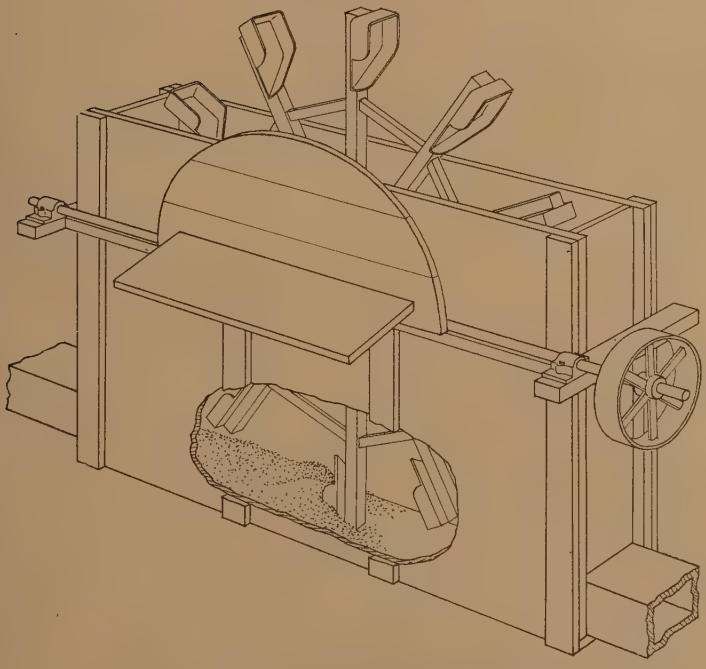


FIG. 11. Sand wheel in tank, broken away to show trough.

palachian region two sand wheels are generally used with two washers, and at many plants they are arranged in two sets, the crude kaolin passing through a washer to a sand wheel and thence through another washer and through another sand wheel into the sand trough. In *A* Plate XXI, streams of water are shown impinging upon the scoops as they are elevated, which loosen the material packed against the walls. The number of washers and sand wheels necessary to separate all the kaolin from the material mined can be determined only by actual test.

"The kaolin comes from the sand wheels thoroughly stirred and at such a rate of speed that much coarse waste is carried in suspension. To prevent this waste passing into the mica troughs, the sand trough or sand box is introduced.

THE SAND TROUGH.

"The sand trough is made in two different styles, the broad trough and the square tank.

"The broad trough, about 2 feet wide and 20 to 30 feet long (see *B* Pl. XXI), is placed absolutely level and the flow of the kaolin-bearing slip is retarded by its distribution and the length of the trough. A barrier 4 to 8 inches high placed at the outlet end of the trough assists in retarding the flow. The coarse sand and the bulk of the coarse mica that passed the sand wheel are thus removed by settling, and the fine material passes to the mica troughs. A workman with a shovel is kept busy removing coarse material from the trough.

"The construction of a sand box or square tank, if one is used instead of the sand trough, is as follows:

"The fine material from the last sand wheel passes through a short trough into one end of a tank 6 feet long, 5 feet wide, and 1 foot deep. The outlet of this tank is 3 inches below the top and is placed either at right angles to the intake or at the same end of the tank as the intake. Thus the entering stream of kaolin-charged water expends its force in the volume of water in the tank and the material that does not settle in making the turn of 45 degrees or more floats off through the outlet into the mica troughs. (See *B* Pl. XXI.) The material that settles is removed from the bottom of the tank with a scoop shovel.

THE MICA TROUGHS.

"The mica troughs are the most important apparatus in a kaolin washing plant. They are constructed in several different designs, although their purpose is in every case the same—that is, the removal of the fine mica and sand.

A. Sand wheels in operation.

B. Tanks and troughs at a washing plant: (*a*) sand trough; (*b*) mica trough; (*c*) concentrating tanks; (*d*) sand wheel.

"The individual troughs are U-shaped and are generally 1 foot wide, 1 foot deep, and 40 to 50 feet long. They are built in batteries, the kaolin slip passing out of one tank into the next, back through that to its extreme end, and thence into the next trough of the battery. Much of the velocity of the kaolin-charged water is expended before the mica troughs are reached, and in order to keep the water moving the troughs are arranged in either of two ways: Each trough may have a drop of 1 inch from end to end, or each trough may be built absolutely level, with a drop of 1 inch between the troughs. In either case the fall is sufficient to maintain a flow. The number of troughs in the battery determines the grade of the product. By adjusting the slope of each trough or the drop between troughs, the grade of product may be regulated. The operation of the mica troughs is necessarily periodic, since to attempt to remove sediment during operation would result in floating off some material already settled and that the troughs are intended to eliminate. The usual way is to use the troughs for about 5 hours continuously, then discontinue the flow of crude kaolin and run clear water through the troughs for 15 to 20 minutes. Then the regular outlet from the troughs is closed and another outlet, which leads to the waste piles, is opened. By means of broad scrapers the sediment in the troughs is pushed out into the waste heap. Then the troughs are flushed clean with water and are ready for operation again. Cleaning takes about an hour and is done during the dinner hour and after the plant closes in the evening.

"An arrangement of the mica troughs that is commonly used in washing clays in England, but is not employed in the United States, is to run the kaolin slips from the sand box into a broad basin from which mica troughs radiate in fan shape, each trough increasing in diameter toward the outer end and thus decreasing the flow. The method of operation and cleaning is the same as that described.

"From the mica troughs the kaolin passes over a screen for removing any very thin flakes of mica that have floated through the troughs.

THE SCREEN.

"There are three general types of screens—stationary, vibrating or sliding, and revolving.

"The stationary screen is most commonly employed in the region studied. (See *A* Pl. XXII.) The screens are arranged in batteries, each screen sloping about 10 degrees and discharging onto a similar screen placed about 6 inches lower. The excess material from the second screen overflows onto a third, and so on. Three screens are generally most efficient in a battery; if necessary, the kaolin slip is divided

and a double, or a larger, battery is put in. The screens are simply built, consisting of box frames about 4 inches high, with brass wire attached to the bottom. An opening 2 inches wide across the lower end of a screen permits the excess material to flow onto the next screen. From the bottom screen the waste falls into a trough which may be emptied when convenient. These screens are all above a concrete or wooden basin, from which the material that passes through the screens runs into concentrating tanks.

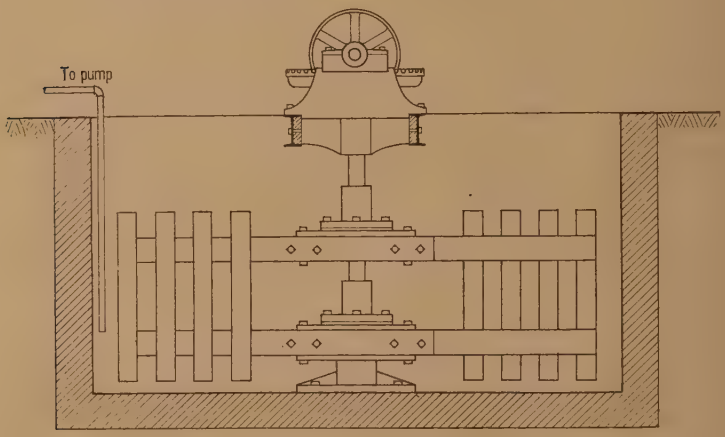


FIG. 12. Agitator used in refining kaolin.

"The vibrating or sliding screen is suspended above a basin and shaken or slid rapidly back and forth by means of an eccentric or similar device, so that the coarse material is kept moving toward one end of the screen while the fine material and liquid passes through into the basin. The worst fault of this type of screen is that its rapid vibration tends to tear the mica flakes into pieces, which pass through the screen with the washed kaolin.

"The revolving screen is a nearly horizontal revolving cylinder, covered with fine screen. Into one end the kaolin slip is run. As the cylinder revolves the slip passes many times around its circumference, the fine kaolin passing through the mesh, while the coarse material gradually works toward the outlet. By adjusting the slope of the cylinder the number of revolutions is regulated through which the material must pass before reaching the outlet. A spray of water from above washes loose any material adhering to the screen and materially increases the

A. Battery of stationary Kaolin screens.

B. End view of Kaolin concentrating tanks.

capacity. Such a screen requires little power and has been found very efficient. The material that passes through runs into a concentrating tank.

CONCENTRATING TANK.

"The concentrating tank is merely a reservoir or a series of reservoirs (see *B* Pl. XXII), in which the kaolin slip stands until it has settled sufficiently to permit drawing off the excess water. Settling is very slow in some cases, and to hasten settling it is customary throughout the region to introduce a flocculator, in the form of alum, into the slip as it passes into the concentrating tanks. The alum in lump form is placed in a muslin bag suspended in the trough leading from the screen. After settling, the excess water is siphoned off and the thick kaolin slip is run into an agitator.

AGITATOR.

"The agitator, which is shown in Fig. 12, is a large cylindrical tank, in the center of which is a shaft with radiating paddles. The paddles stir the kaolin slip into a homogeneous mixture, and in this condition it is pumped from the agitator into the presses.

PUMP.

"The pump used for filling the presses is a simple piston or plunger pump, driven by belt or occasionally by steam direct. The valve and valve seats have to be made of material that will resist abrasion. Valves of rubber and valve seats of bronze are commonly used. An overflow is provided in order that the rate of pumping may be kept at the maximum and the time for filling the presses be reduced to the minimum.

PRESSES.

"The presses were formerly made of wooden plates 30 inches square and 2 to 3 inches thick, hollowed out on each side for a depth of one-half to three-fourths inch. Canvas was stretched over the surfaces and the plates were set in batteries of 50 to 75. To introduce the slip into the openings between the plates, a groove was made through the rim of each plate on the top side, so that when two plates were placed together the opening left was just sufficient to receive a small iron pipe. To allow the water to pass out after being forced through the canvas, a series of small holes was bored through the rim along the lower edge of the plate, and in the face of each plate grooves were cut leading to these outlets. The pressure on these wooden presses never exceeded a few pounds and the removal of water from kaolin slip by their use was very slow.

"All of the plants now operating in the region investigated use a filter press having a heavy cast-iron and steel frame and heavy cast-iron plates. (See *A* Pl. XXIII.) The kaolin slip is introduced through an opening in the center of the plates and the canvas covering is sewed securely about these openings. The outlets for water are the same as in the old wooden presses, but are more numerous. With the presses now used the kaolin slip may be introduced at much higher pressure, and in most cases a pressure of 100 to 120 pounds per square inch is maintained in finishing the filling of a press. After the press is filled with solid kaolin the pump is stopped, the screw that holds the press plates together is withdrawn, and the cakes of pressed kaolin are removed. The cakes are not absolutely dry, but contain from 8 to 20 per cent water, hence additional drying is necessary before the kaolin is ready for shipment.

DRIERS.

"The final drying of kaolin is accomplished by three different devices: Open-air driers, steam driers, and tunnel driers.

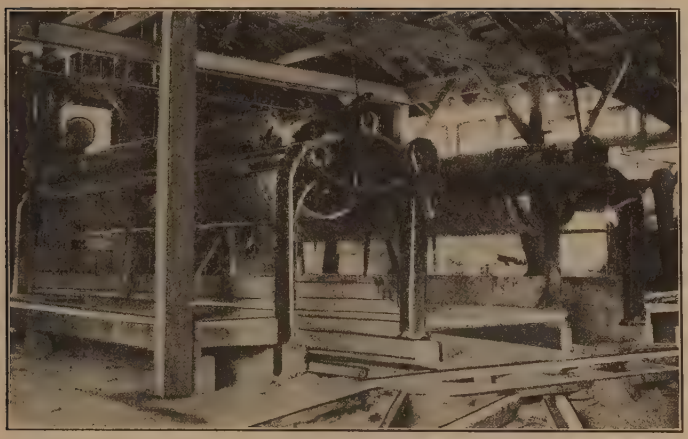
"An open-air drier consists merely of a building containing racks on which the kaolin cakes may be exposed to the air and the moisture gradually evaporated.

"A steam drier consists of an open building, on the floor of which are placed steam pipes connected at one end with heaters. (See *B* Pl. XXIII.) The damp kaolin is dumped directly upon these pipes, where it dries. When dry, the kaolin is shoveled off the pipes and is loaded directly into cars or wagons for shipment.

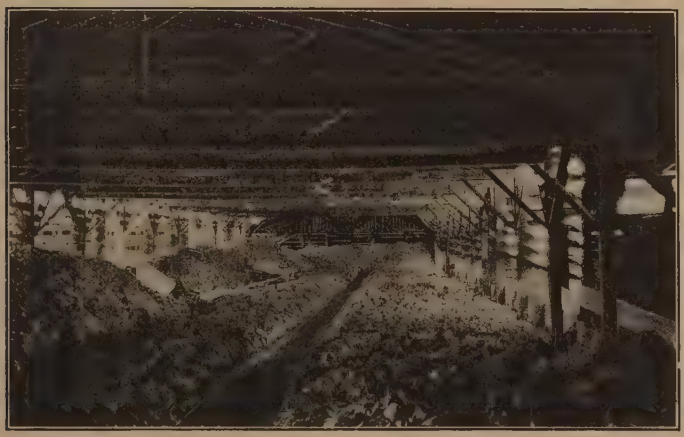
"The tunnel drier is a device borrowed from modern brick making. On removal from the filter press the cakes of damp kaolin are loaded upon rack cars, which hold about 1 ton each. These cars are run into the drier, which is so constructed that the cars run by gravity toward the outlet. As a car of damp kaolin enters the drier a car of kaolin that has been dried is taken from the opposite end. The method of heating the air for this type of drier varies. The system used in this region is to force the air by fan through steam coils and into the drier.

ANALYSES OF FELDSPAR, SEMIKAOLINIZED FELDSPAR, KAOLIN, OCHER, SCHROETTERITE, QUARTZ, AND WAD.

"Analyses of feldspar, semikaolinized feldspar, kaolin, ocher, schroetterite, quartz, and wad are presented below. These analyses have been collected from various sources, as the references indicate. Elements other than those mentioned were not sought by the analysts.



A. Elevated filter presses.



B. Steam Dryer, showing car track in center and Kaolin on the steam pipes, which are laid directly on the floor.

Analyses of feldspars.

Mine.	H_2O.	SiO_2.	Al_2O_3.	Fe_2O_3	TiO_2.	CaO.	MgO.	BaO.	Na_2O.	K_2O.	Total.
Witherspoon mica mine, Ashe County, N. C.*	0.90	64.48	19.43	0.01	Trace	Trace	Trace	0.00	1.84	13.19	99.85
Avery Meadow mica mine, Avery County, N. C.†‡	.....	62.95	19.66	.....	.....	Trace	.....	.....	7.64	8.39	.....
Plumtree mica mine, Avery County, N. C.*	.17	65.37	17.92	.02	Trace	.17	Trace	.00	2.10	13.05	98.80
Lisle Knob mica mine, Macon County, N. C.*	.30	65.40	20.70	.10	Trace	1.60	Trace	.00	6.10	6.00	100.20
McGuire Prospect, Macon County, N. C.*	.60	63.90	19.97	.15	Trace	.05	Trace	.70	1.01	13.20	99.58
Southern Clay Co. mine, Macon County, N. C.*	.50	64.30	19.64	.08	Trace	Trace	Trace	.17	1.32	14.00	100.01
Carolina Mineral Co. (Albite), Mitchell County, N. C.*	1.00	64.92	22.28	.21	Trace	1.60	Trace	.00	9.20	1.10	100.31
Carolina Mineral Co. (Microcline), Mitchell County, N. C.*	.30	65.68	19.08	.14	Trace	Trace	Trace	.00	2.08	13.09	100.37
Cloudland mica mine, Mitchell County, N. C.†‡	.....	65.18	21.60	.....	.....	.64	.....	.....	8.35	.04	.....
Cook mica mine, Mitchell County, N. C.*	.40	64.93	19.45	Trace	Trace	.05	Trace	.00	2.54	12.46	99.83
Flat Rock mica mine, Mitchell County, N. C.†‡	.....	65.15	19.04	.....	.....	.12	.....	.....	7.00	7.28	.....
Wiseman mica mine, Mitchell County, N. C.†‡	.....	64.85	19.90	.....	.....	.00	.....	.....	10.04	2.91	.....
Granite from Mitchell County, N. C.*	.90	75.10	15.57	.47	.03	1.10	Trace	.00	2.86	3.49	99.52
Ray mica mine, Yancey County, N. C.*	.20	68.18	20.12	.05	Trace	.85	.05	.00	9.38	.66	99.49
Do.†‡	.....	63.55	20.20	.....	.....	Trace	.....	.....	6.65	8.73	.....
McNichols Co. mine, Bedford County, Va.*	.10	68.75	18.56	.03	Trace	1.25	Trace	.00	4.29	6.85	99.83

*Analysis by Prof. D. J. Demorest, Ohio State University.
†Elements not mentioned were not sought.
‡Analysis by the North Carolina Geological Survey.

Analyses of semikaolinized feldspars.

(D. J. Demorest, analyst.)

Mine.	H_2O.	SiO_2.	Al_2O_3.	Fe_2O_3	TiO_2.	CaO.	MgO.	BaO.	Na_2O.	K_2O.	Total.
Forest Hill mica mine, Jackson County, N. C.	0.90	63.35	20.07	0.15	Trace	0.03	Trace	0.00	1.11	13.70	99.31
Moore mica mine, Macon County, N. C.	2.05	63.74	20.90	.12	Trace	Trace	Trace	1.10	.19	11.70	99.80
Southern Clay Co. mine, Macon County, N. C.	1.40	62.47	21.00	.05	Trace	Trace	Trace	.30	.90	13.62	99.74
Seth Freeman prospect, Madison County, N. C.	5.42	65.05	22.39	.29	.12	Trace	Trace	.30	.21	6.53	100.31
Flukin Ridge mica mine, Mitchell County, N. C.	1.34	63.32	20.45	.07	Trace	Trace	Trace	.00	.80	14.20	100.18
Isinglass Hill mica mine, Rutherford County, N. C.	3.60	60.47	23.45	.10	Trace	Trace	Trace	.00	.65	12.10	100.37
Harris Clay Co., Bryson City mine, Swain County, N. C.	.94	63.60	20.40	.32	Trace	Trace	Trace	.00	.50	14.40	100.16

Analyses of kaolins.

(D. J. Demorest, analyst.)

Mine.	H_2O.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	CaO.	MgO.	BaO.	Na_2O.	K_2O.	Total.
Kinsland mine, Haywood County, N. C.	11.90	50.64	35.57	0.25	0.03	Trace	Trace	0.07	0.08	1.70	100.24
Buchanan prospect, Jackson County, N. C.	13.77	46.30	39.06	.20	.04	Trace	Trace	.00	.11	.60	100.08
Forest Hill mica mine, Jackson County, N. C.	12.53	49.20	37.58	.17	Trace	Trace	Trace	.00	.13	.47	100.08
Harris Clay Co., Dillsboro mine, Jackson County, N. C.	13.99	46.95	37.73	.15	.05	Trace	Trace	.00	.18	.60	99.65
Piedmont Tin Mining Co., Lincoln County, N. C.	12.00	48.50	37.35	.85	Trace	Trace	Trace	.00	.32	1.02	100.04
Gurney Clay Co., Macon County, N. C.	14.72	44.00	40.79	.11	Trace	Trace	Trace	.00	.07	.55	100.24
McGuire prospect, Macon County, N. C.	14.00	46.35	39.00	.30	Trace	Trace	Trace	.00	.00	.50	100.15
Raby mica mine, Macon County, N. C.	13.80	46.90	38.60	.25	Trace	Trace	Trace	.00	.26	.39	100.20
J. J. Smith prospect, Macon County, N. C.	12.55	48.05	37.69	.31	Trace	Trace	Trace	.00	.02	.91	99.53
Southern Clay Co., Macon County, N. C.	13.22	46.67	39.07	.11	.02	Trace	Trace	.00	.11	.25	99.45
West prospect, Macon County, N. C.	12.70	48.92	36.37	.37	.02	Trace	Trace	.00	.11	.29	98.78
Harris Clay Co., Spruce Pine mine, Mitchell County, N. C.	14.80	45.20	38.45	.45	Trace	Trace	Trace	.00	.00	.65	99.55
Tolley mica mine, Mitchell County, N. C.	14.00	46.35	38.80	.25	Trace	Trace	Trace	.03	.00	.41	99.84
Harris Clay Co., Bryson City mine, Swain County, N. C.	14.10	46.95	37.24	.40	.05	Trace	Trace	.00	.24	.49	99.47
Elizabeth Smith mica mine, Yancey County, N. C.	13.10	45.95	39.20	.05	Trace	Trace	Trace	.03	Trace	.50	98.83

*Analyses of ocher, schroetterite, sugar quartz, and wad.**

(D. J. Demorest, analyst.)

Material and Locality.	Loss on Ignition.	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	Na_2O.	K_2O.	Mn_3O_4.	CaO+NiO.	CuO.
Ocher, Yonce prospect, Macon County, N. C.	13.59	15.40	16.25	51.00	0.30					
Schroetterite, Jackson County, N. C.	28.10	21.90	49.60	.30			0.10			
Sugar quartz, Macon County, N. C.	.10	99.32	.49	Trace						
Wad, Macon County, N. C.	15.30	33.20	24.60	4.00	.25			21.80	0.75	0.50

*Elements not mentioned were not sought.

DESCRIPTION OF MINES CONTAINING FELDSPAR OR SEMIKAOLINIZED FELDSPAR AND KAOLIN.

FELDSPAR MINES AND PROSPECTS.

INTRODUCTION.

Many of the mines that are now producing feldspar or kaolin were formerly opened as mica mines; and even to-day, though they are being mined particularly for the first mentioned minerals, they are producing considerable mica. It will be noticed in the description of the mines below that nearly all of them are known as mica mines.

BAKERSVILLE. BUCKEYE MICA MINE.

"This mine is at the head of White Oak Creek, 5 miles southeast of Bakersville, Mitchell County, N. C. This dike is about 8 feet wide, and, near the surface, is almost pure feldspar, but the feldspar apparently forms a lens and pinches out at a depth of about 10 feet, below which is pegmatite. The dike strikes north and dips almost vertically. An inclined tunnel has been driven into this dike and its face is reported to be 40 feet below surface, but this tunnel is filled with water and there is no other way to ascertain whether the lower portions of the dike contain pure feldspar.

BAKERSVILLE. CLOUDLAND MICA MINE. ALBITE.

"This mine is on the north face of a spur of Yellow Mountain 400 feet above the Bakersville-Plumtree road, 1 mile south of the road and 5 miles east of Bakersville, Mitchell County, N. C. The nearest shipping point is Toecane, 2 miles west of Bakersville.

"This pegmatite dike averages 14 to 16 feet in diameter, the mica running chiefly along the walls. It strikes N. 40° E. and dips 75° SE. Adjoining the walls are numerous bands of pegmatite very low in feldspar and carrying large amounts of garnet, tourmaline, beryl, biotite, mica, and other impurities. This dike has been opened for 120 yards and to a depth of 70 feet in places. The open-cut averages about 35 feet deep. The high-grade feldspar band in the middle of this dike averages about 4 feet thick and has the following chemical composition:

Composition of high-grade feldspar band.[1]

SiO_2	65.18
Al_2O_3	21.60
K_2O	.04
Na_2O	8.35
CaO	.64
	95.81

[1]See North Carolina Geol. Surv., Economic Paper No. 6, p. 49.

"This feldspar has a deformation temperature ranging from 1,295° to 1,300° C., and produces a milk-white glass when fused.

Properties in standard porcelain mixture.

In this mixture the feldspar produces vitrification at 1,300° C., and at 1,350° shows slight warping. The color is equal to the standard trial. The translucency is 0.69 and the transmitted light is cream colored. The total shrinkage is 15.3 per cent in the mixture fired to 1,350°, 3 per cent drying shrinkage, and 12.3 per cent firing shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

BAKERSVILLE. LICK RIDGE MICA MINE.

"This mine is 2 miles northeast of Bakersville, Mitchell County, N. C., on Lick Ridge, a spur of Pumpkin Patch Mountain.

"The dike is a mixture of feldspar and pegmatite. The feldspar band in the upper portion of the exposure is as much as 8 feet thick, but rapidly narrows and at a depth of about 10 feet practically pinches out, being replaced by pegmatite. The dike strikes north and is exposed about 60 feet. Since the depth of the exposure is only 10 feet, not enough material is exposed to justify an opinion as to the advisability of mining operations and therefore no sample was taken.

BAKERSVILLE. J. T. WILSON MICA MINE.

"This prospect is 2 miles southeast of Bakersville, Mitchell County, N. C., on White Oak Creek.

"The pegmatite dike is 15 to 18 feet wide and is exposed about 60 feet along the slope of a hill that runs to the northeast. The dike strikes N. 20° E. Along the walls there is mica, but the mica-bearing pegmatite is never more than 4 feet wide, leaving a band of practically pure feldspar. A stream, however, has followed the dike down the hill and has so thoroughly percolated the dike that attempts to obtain satisfactory samples by removing a reasonable amount of the outer portion of the dike failed. No feldspar has been taken out, therefore no sample was taken.

BANDANA. OLD GOUGE MICA MINE. ANORTHOCLASE.

"This mine is on a ridge 150 feet above the Bandana-Penland road and 1 mile southeast of Bandana, Mitchell County, N. C. Galax, the nearest shipping point, is 2½ miles distant. This dike is about 3 feet wide where exposed and has been worked for a distance of 60 feet by open-cut. The pegmatite carries little quartz and a few scattered garnets. The mica is found chiefly along the walls. The dike strikes west and dips 75° S. The feldspar sampled is white and of high luster. Its deformation-temperature range is from 1,300° to 1,310° C., and it fuses to a semitransparent glass free from yellow tint.

Properties in standard porcelain mixture.

In this mixture the feldspar produces vitrification at 1,300° C., and at 1,350° produces slight warping. The color is equal to that of the standard trial. The translucency at 1,350° C. is 0.71 and the transmitted light is cream colored. Shrinkage of the plastic molded mixture from green to 1,350° C. is 15 per cent, the drying shrinkage being 3 per cent and the firing shrinkage 12 per cent. Under the raw-lead and fritted glazes the color is unaltered.

BEAVER CREEK. HAMILTON MICA MINE. MICROCLINE.

"This mine is 2 miles northwest of Beaver Creek, Ashe County, N. C., on Elk Mountain. The nearest railroad is at Shouns Crossroads 23 miles northwest, too far for haulage.

"It is a very coarse pegmatite dike averaging 6 to 8 feet thick, rich in feldspar, but never free from quartz particles. However, the feldspar appears to be uniform in quality. The strike is N. 20° E., and the dip 80° E. The mica is present in some parts of this dike as isolated pockets, in others scattered through the pegmatite, rendering those parts worthless as a source of feldspar. The dike material was sampled where free from mica. The tests gave the following results:

"Deformation temperature range, 1,290° to 1,310° C. Color, when fused, free from yellow tint; only a slight milkiness.

Properties in standard porcelain mixture.

In the mixture this feldspar produces a vitreous mass at 1,300° C., and at 1,350° a very slight warping occurs. The color is equal to the standard trial. Fired at 1,350° C. it has a translucency of 0.66 and the transmitted light is cream colored. The total shrinkage is 15.8 per cent, drying shrinkage 3.4 per cent, and firing shrinkage 12.4 per cent. Under the raw-lead and fritted glazes the color is unaltered.

BEAVER CREEK. NORTH HARDIN MICA MINE. MICROCLINE.

"This mine is 1½ miles west of Beaver Creek, Ashe County, N. C. The nearest shipping point is Shouns Crossroads, 24 miles northwest. This is too far for road haulage.

"It is a narrow dike that has been worked extensively along the surface for mica. The strike is N. 20° E. and the dip 70° to 80° E. The dike averages about 6 feet thick and contains a band of microcline from 1 to 4 feet thick. A narrow band of anorthoclase is also present in a number of places. The wall rock is solid gneiss. The feldspar of this dike is very free from impurities, which are chiefly quartz and mica and a few scattered iron garnets. The microcline has a deformation temperature ranging from 1,295° to 1,310° C. When fused it becomes practically clear and shows no yellow tint.

Properties in standard porcelain mixture.

This feldspar in the mixture produces a vitreous mass at 1,300° C., and at 1,350° shows a slight tendency to warp. Its color is equal to the standard. Fired at 1,350° C. this feldspar produces a translucency of 0.74, and the transmitted light is cream colored. Total shrinkage is 16 per cent, drying shrinkage 3 per cent, and firing shrinkage 13 per cent. Under the raw-lead and fritted glazes the color is unaltered.

BURNSVILLE. RAY MICA MINE. ALBITE.

"This mine, which has been one of the most productive mica mines in the county, is 3 miles southeast of Burnsville, Yancey County, N. C., on the south face of a ridge that runs off from Black Mountain. The nearest shipping point is Micaville, 4 miles east. The workings are scattered along the slopes of a cove and are all on the same dike, which strikes N. 40° E. and dips 85° SE. The dike has in the center a clean feldspar band averaging 5 feet wide, and numerous narrow bands with more or less quartz on both sides. Some of these narrow bands are separated from one another by thin quartz bands, but a large part of the dike could be hand cobbed and marketed as feldspar.

"The upper portion of the mine has been worked by open-cut to a depth of 40 feet, below which shaft mining has been carried on to a depth of 110 feet. The dumps of this shaft consist very largely of marketable feldspar, which was sampled and analyzed with the following result:

Chemical analysis.

H_2O	0.20
SiO_2	68.18
Al_2O_3	20.12
Fe_2O_3	.05
TiO_2	Trace.
CaO	.85
MgO	.05
K_2O	.66
Na_2O	9.38
	99.49

Chemical analysis in 1901.[1]

Sio_2	63.55
Al_2O_3	20.20
K_2O	8.73
Na_2O	6.65
	99.13

[1]See Economic Paper No. 6, North Carolina Geol. Surv., pp. 49-50.

"The albite, which was exposed in abundance during the summer of 1911, has been tested with the following results:

"Deformation temperature range, 1,270° to 1,275° C.; color, when fused at 1,330° C., an opaque white with no yellow tint.

Properties in standard porcelain mixture.

In this mixture the feldspar gives a vitreous mass at 1,275° C. and warps slightly at 1,330° C. The color is slightly bluish by comparison with pure-white trials. Fired at 1,350° C. the translucency is 0.65 and the transmitted light is cream colored. The total shrinkage at 1,350° C. is 15 per cent, which consists of 3 per cent drying shrinkage and 12 per cent firing shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

FRANKLIN. BURNINGTOWN MICA MINE. MICROCLINE.

"This mine is 3 miles southeast of Burningtown Bald, Macon County, N. C. The nearest shipping point is Franklin, Macon County, N. C.

"The mine is in a pegmatite dike, rich in feldspar, and averages about 8 feet wide, which has in the middle a quartz band varying from 2 feet to 3 feet wide. Other lenses of quartz are numerous. The strike is generally west; the dip 80° N. Mica is found chiefly along the walls, and the main portion of the pegmatite is very clean. Mining has been for mica only. A similar feldspar is found in small quantity in the Wayah Bald mica mines, which are 3 miles southwest.

"The mine comprises an open-cut 150 feet long and a tunnel 300 feet long penetrating the dike 125 feet. The pegmatite has a deformation temperature ranging from 1,305° to 1,320° C. Color, slightly milky when fused, but free from yellow tint.

Properties in standard porcelain mixture.

In the standard porcelain mixture this pegmatite gives a vitreous mass at 1,310° C. and warping is very slight at 1,350.° Color is equal to the standard trial. Translucency at 1,350° is 0.65. Transmitted light is cream colored. Shrinkage in the standard plastic porcelain mixture is 15.3 per cent, green to 1,350.° Under the raw-lead and fritted glazes the color is unaltered.

FRANKLIN. CAMPBELL-HIGDON MICA MINE. MICROCLINE.

"This mine is 1½ miles west of Watauga Gap on Cowee Mountain, Macon County, N. C. Franklin, Macon County, is 9 miles southwest, and Dillsboro, Jackson County, is 12 miles northeast of this mine. Franklin has the advantage of better roads and shorter haul and Dillsboro the advantage of a slightly lower freight rate to northern markets.

"The pegmatite is cut by two tunnels, and at one point is 10 feet thick, with a 4-foot quartz band in the center. Owing to a thick overburden of

loose ground, mining has been very difficult. Since the most productive workings are partly kaolinized material adjoining the wall rock, the fresh pegmatite has not been thoroughly exposed, and its extent cannot be estimated. The operations are, however, on a steep mountain side, and the loose material could be economically removed in case open-cut mining for feldspar should be attempted.

"The feldspathic portion of this dike has a deformation temperature ranging from 1,305° to 1,320° C., and on deformation becomes a pale milky white without yellow tint.

Properties in standard porcelain mixture.

In this mixture the feldspar produces vitrification at 1,300° C., and at 1,350° shows very slight warpage. The color is similar to the standard trial. The translucency, is 0.67 and the transmitted light is cream colored. The shrinkage in plastic mixture, from green to 1,350° C., is 15.7 per cent. Under the raw-lead and fritted glazes the color is unaltered.

FRANKLIN. LISLE KNOB MICA MINE. ALBITE AND ANORTHOCLASE.

"This mine is on the southwest face of Lisle Knob, 1½ miles east of the Little Tennessee River and 5 miles north of Franklin, Macon County, N. C., which is the nearest shipping point. The deposit is a pegmatite lens about 30 feet thick and is opened by tunnel for a length of 75 feet and a depth of 35 feet. The strike is N. 10° E. and dip is 80° W. The east half of the lens contains many quartz bands and numerous clusters of iron garnets, but the west half is very clean except for iron garnets, which would necessitate careful sorting to obtain the highest possible grade of product. This lens is covered with about 40 feet of loose overburden, but the wall rock is a solid gneiss.

"This deposit was carefully sampled; the feldspar was found to have the following chemical composition:

Chemical composition.

H_2O	0.30
SiO_2	65.40
Al_2O_3	20.70
Fe_2O_3	.10
TiO_2	Trace.
CaO	1.60
MgO	Trace.
K_2O	6.00
Na_2O	6.10
	100.20

"The deformation temperature ranges from 1,260° to 1,265° C.; the color after fusion is dull white, free from yellow tint.

Properties in standard porcelain mixture.

In this mixture the feldspar gives a vitreous mass at 1,265° C., and warps slightly at 1,350°. The color is slightly blue by comparison with the standard trial. Translucency is 0.72 and transmitted light is cream colored. Total plastic shrinkage, when fired to 1,350° C., is 15.9 per cent. Under the raw-lead and fritted glazes the color is unaltered.

FRANKLIN. M'GUIRE PROSPECT. MICROCLINE.

"This prospect is at the head of McGuire Cove, on the southwest face of Tremont Mountain, 4 miles northwest of Franklin, Macon County, N. C., and 1 mile north of and 500 feet above the Franklin Andrews road. The nearest shipping point is Franklin. The formation is a dike of feldspar 10 feet in diameter where exposed, and bisected vertically by a band of sugar quartz 2 feet thick. This dike strikes southwest and dips south. The wall rock is Carolina gneiss, and at this point is very solid. The deposit is opened the width of the dike, and for a height of 15 feet and a depth of 8 feet into the mountain. An average sample of this deposit shows the following chemical composition:

Chemical composition.

H_2O	0.60
SiO_2	63.90
Al_2O_3	19.97
Fe_2O_3	.15
TiO_2	Trace.
CaO	.05
MgO	Trace.
K_2O	13.20
Na_2O	1.01
BaO	.70
	99.58

"The deformation temperature range is 1,315° to 1,330° C. Color is milky when fused, but free from yellow tint.

Properties in standard porcelain mixture.

In the mixture this feldspar gives a vitreous mass at 1,310° C., and at 1,350° no warping is noted. The color is slightly, but positively, superior to the standard trial. Translucency at 1,350° C. is 0.68. Transmitted light is cream colored. Shrinkage in standard plastic porcelain mixture is as follows: Green to 1,350° C., 14.7 per cent. Under the raw-lead and fritted glazes the color is unaltered.

FRANKLIN. NEAL BRYSON MICA MINE. ALBITE.

"This mine is on the Franklin-West Mills road, on the east bank of the Little Tennessee River, 6 miles north of Franklin, Macon County, N. C., which is the nearest shipping point. The dike is from 2 to 12 feet wide. It strikes west and dips 70° N. at the east end and 30° S. at the west end. This mine has been worked only for mica, which generally follows the south wall. The dike is a feldspar-rich pegmatite, and has in the middle a quartz band varying in thickness from a few inches to about 3 feet. Mining operations consist of a number of shafts about 70 feet above the road and a tunnel crosscutting the dike at the road level. From the shafts the dike material was removed by stoping until the cutting of the tunnel recently made possible the removal of the material from below. The abandoned stopes in the old workings are filled with feldspar and quartz bowlders, but much feldspar has been dumped about the mouth of the shafts and the entrance to the tunnel.

"The feldspar of this dike has a deformation temperature ranging from 1,295° to 1,300° C. As mined, it has a peculiar blue-gray tint but on fusing it becomes a pale-cream enamel.

Properties in standard porcelain mixture.

In this mixture the feldspar gives a vitreous mass at 1,300° C., and only a trace of warping at 1,350.° The color is slightly bluish, but is not discernible except by comparison with pure-white trials. In the porcelain mixture the translucency is 0.65 and the transmitted light is cream colored. The shrinkage, green to 1,350° C., is 15 per cent in standard plastic mixture. Under the raw-lead and fritted glazes the color is unaltered.

FRANKLIN. SHEFFIELD MICA MINE. MICROCLINE.

"This mine is 2 miles north of Franklin, Macon County, N. C., on the east bank of the Little Tennessee River, in a dike about 12 feet wide which strikes west and dips 80° N. The dike consists of a number of distinct bands. The one adjoining the south wall is a low-grade pegmatite and carries the mica. A band of pegmatite rich in feldspar joins this on the north, and adjoining this is a band or lens of pure feldspar. This is separated from the north wall by a band of quartz. The feldspar-rich pegmatite where exposed is about 4 feet thick and the feldspar is 2½ feet thick.

"Mining is difficult because the mine is below the level of the river during the winter months and water fills all openings.

"The deformation temperature range of this feldspar is from 1,315° to 1,330° C. Color, milky when fused, but free from yellow tint.

Properties in standard porcelain mixture.

In this mixture the feldspar gives a vitreous mass at 1,320° C., and at 1,350° shows no warping. Color is equal to the standard trial. Translucency fired at 1,350° is 0.67 with a cream tint. Total shrinkage is 14.8 per cent. This consists of 3 per cent drying shrinkage and 11.8 per cent firing shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

FRANKLIN. SOUTHERN CLAY COMPANY MINE. CRYSTALLINE ORTHOCLASE.

"The orthoclase was obtained from beneath the Southern Clay Company kaolin deposit at Franklin, Macon County, N. C. It occurs as clearly defined orthoclase crystals of milk-white color and was pulverized to pass a 150-mesh brass screen.

Chemical composition.

H_2O	0.50
SiO_2	64.30
Al_2O_3	19.64
Fe_2O_3	.08
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
BaO	.17
K_2O	14.00
Na_2O	1.32
	100.01

"This feldspar has a deformation temperature ranging from 1,305° to 1,325° C., and when fused to a glass becomes clear and without a trace of color that can be detected by the eye.

Properties in standard porcelain mixture.

In the mixture this feldspar shows vitrification at 1,300° C., and at 1.350° only a slight warpage. The color is a purer white than that of the standard trial. The translucency is 0.67. Total plastic shrinkage is 13.8 per cent when fired to 1,350.° Under the raw-lead and fritted glazes the color is unaltered.

GALAX. YOUNG AND RAY PROSPECT.

"This prospect is on the Black Mountain Railroad between Galax, Mitchell County, and Micaville, Yancey County, N. C. The pegmatite is a coarse aggregate of feldspar and quartz with a liberal sprinkling of biotite and garnet. The greatest width of the 'deposit' is 200 to 250 yards, but approximately one-half of this width is country rock and the remainder comprises lenses and bands of pegmatite of varying

widths; the broadest area recorded is four bands, all of impure pegmatite but free from wall material, which has a total width of 75 feet. The only band of pure feldspar recorded is one 6 feet in width in the middle of this 75-foot pegmatite area.

JEFFERSON. COLDIRON PROSPECT.

"This prospect is 3½ miles northeast of Jefferson, Ashe County, N. C., and due southeast from the Witherspoon mica mine. The dike where exposed is pegmatite, about 50 per cent feldspar and 50 per cent quartz, and contains few garnets or other objectionable material. The face of the dike for a depth of 15 feet is exposed along the south side of the Jefferson-Spartan road. The width of the dike is 15 to 18 feet. There are no pure feldspar bands and the mine is 25 miles from the railroad. No further examination was made.

JEFFERSON. WITHERSPOON MICA MINE. MICROCLINE.

"This mine is on the southeast face of Little Phœnix Mountain, 3½ miles northeast of Jefferson, Ashe County, N. C., and one-half mile north of the Jefferson-Sparta road.

"The pegmatite dike is about 10 feet thick and strikes N. 40° E. The dip of the exposed portion is vertical. Mica had been mined at two points about one-fourth mile apart previous to 1901. The dike is chiefly feldspar. The mica is largely in the bands adjoining the wall rock and no associated minerals besides quartz are noted. The feldspar band of this deposit was sampled and analyzed. The chemical composition is as follows:

Composition of feldspar.

H_2O	0.90
SiO_2	64.48
Al_2O_3	19.43
Fe_2O_3	.01
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
K_2O	13.19
Na_2O	1.84
	99.85

"The deformation temperature range is from 1,290° to 1,310° C. When fused the feldspar shows only a trace of cloudiness and is free from yellow tint.

Properties in standard porcelain mixture.

In the mixture this feldspar produces a vitreous mass at 1,300° C., and at 1,350° shows very slight, if any, warping. The color is fully equal to the standard trial. Fired at 1,350° C. this mixture has a translucency of 0.72 and the transmitted light is cream colored. Total shrinkage of 15.4 per cent, drying shrinkage 3 per cent and firing shrinkage 12.4 per cent. Under the raw-lead and gritted glazes the color is unaltered.

PENLAND. CAROLINA MINERAL COMPANY MINE. MICROCLINE AND ALBITE.

"A broad lens is exposed on both sides of the North Toe River, one-fourth mile east of the railroad station at Penland, Mitchell County, N. C. The dike that includes this lens strikes about west; on the north side of the river it dips 75° to 80° S., and on the south side 80° to 85° S. The dike is 15 to 35 feet wide and contains isolated lenses of soda feldspar, but most of the dike is microcline. It contains little quartz, which is present chiefly as bands along the walls or as isolated lenses. Mica is found in pockets, and in places garnets are associated with the mica. Uranium-bearing minerals are also present, and many nugget-like masses containing pitch-blende have been found in mining operations. Small quantities of beryl also have been found.

"Quarrying began in the spring of 1911. Regular quarrying methods have been used so far, tunnels being used for prospecting purposes only. A depth of 50 feet has been reached. The deposit remains uniform to that depth, with no indication of narrowing.

"An average sample of the microcline constituting this dike was analyzed, and is as follows:

Composition of microcline.

H_2O	0.30
SiO_2	65.68
Al_2O_3	19.08
Fe_2O_3	.14
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
K_2O	13.09
Na_2O	2.08
	100.37

"This feldspar has a deformation temperature ranging from 1,290° to 1,310° C. It fuses to a glass with only a trace of milkiness and no yellow tint.

Properties in standard porcelain mixture.

In the mixture this feldspar produces a vitreous mass at 1,295° C.; at 1,350° no warping is apparent. The color is fully equal to the standard trial. When fired at 1,350° C. the translucency is 0.69 and the transmitted light is cream colored. The total shrinkage at 1,350° is 15.6 per cent, 3.6 per cent being drying shrinkage and 12 per cent firing shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

"An average sample of the albite in this dike is found to have the following chemical composition:

Composition of albite.

H_2O	1.00
SiO_2	64.92
Al_2O_3	22.28
Fe_2O_3	.21
TiO_2	Trace.
CaO	1.60
MgO	Trace.
K_2O	1.10
Na_2O	9.20
	100.31

"The deformation temperature range is from 1,260° to 1,265° C. At 1,350° the feldspar fuses to a dull white mass.

Properties in standard porcelain mixture.

In the mixture this feldspar produces a vitreous mass at 1,265° C., and at 1,330° there is a slight warping. The color of the porcelain at 1,350° is bluish when compared with the standard trial. The translucency at 1,350° is 0.65; the transmitted light is cream colored. The total shrinkage is 14.8 per cent, which is 2.4 per cent drying shrinkage and 12.4 per cent firing shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

PENLAND. FLAT ROCK MICA MINE. MICROCLINE.

"This mine is 1½ miles northeast of Penland, Mitchell County, N. C. The dike is from 8 to 12 feet thick, the center only being pure feldspar, which is from 4 to 6 feet wide. The dike strikes N. 35° E. and dips 80° SE. It is more or less altered to a depth of about 30 feet, below which the material is fresh.

An analysis of this feldspar, made by the North Carolina Geological Survey,[1] is as follows:

[1]See North Carolina Geol. Surv. Economic Paper No. 6, p. 49.

Composition of feldspar.

SiO_2	65.15
Al_2O_3	19.04
CaO	.12
Na_2O	7.00
K_2O	7.28
	98.59

This deposit has only recently been worked for feldspar.

PLUMTREE. AVERY MEADOW MICA MINE. ANORTHOCLASE.

"This mine is 1½ miles north of Plumtree, Avery County, N. C., and one-half mile west of North Toe River, the nearest shipping point being 8 miles southwest at Spruce Pine. It has been worked extensively for mica. The coarse pegmatite dike carries a 4-foot band of clean feldspar midway between the walls. There is a band of nearly equal width of high-grade pegmatite adjoining the feldspar. The dike strikes N. 40° W. at the entrance to the tunnels, but farther in the strike varies, although always having a general northwest direction. This feldspar has no undesirable associated minerals, except the quartz and mica, which are not mixed with the feldspar, but are confined chiefly to those bands of the dike that adjoin the walls.

"The great drawback to the mining of the feldspar is the fact that work would have to be under ground, since the overburden exceeds 50 feet in all places and is more than 100 feet deep over most of the dike.

"The chemical composition of the feldspar from this deposit is reported as follows:

Composition of feldspar.[1]

SiO_2	62.95
Al_2O_3	19.66
K_2O	8.39
Na_2O	7.64
	98.64

"The feldspar of this deposit was sampled and tested. It deforms only from 1,325° to 1,350° C., which is at least 30 degrees higher than might be expected from the analysis. Its color is slightly creamy when fused.

[1]See Pratt, J. H., "The Mining Industry in North Carolina During 1901," North Carolina Geol. Surv. Economic Paper No. 6, pp. 49-50.

Properties in standard porcelain mixture.

In the mixture the feldspar produces a vitreous mass at 1,330° C.; it shows no warpage at 1,350° C. Its color, however, is grayish when fired to 1,350° C. Its translucency is 0.60 when fused at 1,350°, and its total shrinkage is 16 per cent. Under the raw-lead and fritted glazes the color is unaltered.

PLUMTREE. JOHNSON MICA MINE. MICROCLINE.

"This mine is 2 miles east of Plumtree, Avery County, N. C., on Plumtree Creek. Spruce Pine, the nearest shipping point, is 10 miles southwest.

"There is a pegmatite dike of variable thickness, containing a band of microcline from 2 to 4 feet wide midway between its walls. The dike strikes northwest and dips 5° to 25° NE.

"The feldspar band is very narrow but is free from impurity. The pegmatite band that joins the feldspar is also free from scattered mica and low in quartz.

The feldspar collected has a deformation temperature ranging from 1,270° to 1,290° C. When fused it is practically clear and has no yellow tint.

Properties in standard porcelain mixture.

In the mixture the feldspar produces a vitreous mass at 1,275° C., and no warping at 1,350°. Its color is pure white. When fired at 1,350° C. it gives the porcelain a translucency of 0.73, cream colored, and a total shrinkage of 15.4 per cent, 3 per cent drying shrinkage and 12.4 per cent burning shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

PLUMTREE. PLUMTREE MICA MINE. MICROCLINE.

"The mine is one-half mile east of Plumtree, Avery County, N. C., on Plumtree Creek, 8 miles northeast of Spruce Pine, which is the nearest shipping point. A pegmatite dike 10 to 15 feet wide was exposed, first by regular open-cut methods and later by hydraulic mining. The overburden ranges from 3 to 6 feet deep. The central portion, averaging 5 to 6 feet wide, is pure feldspar with only a scattering of quartz. The dike strikes N. 25° W. and dips 30° NE. The open-cut and hydraulic mining have exposed a large amount of microcline. The feldspar was sampled and analyzed as follows:

Composition of feldspar.

H_2O	0.17
SiO_2	65.37
Al_2O_3	17.92
Fe_2O_3	.02
TiO_2	Trace.
CaO	.17

MgO	Trace.
K_2O	13.05
Na_2O	2.10
	98.80

"The deformation temperature range of this feldspar is 1,270° to 1,290° C. When fused the feldspar is practically clear and without a tint of yellow.

Properties in standard porcelain mixture.

In the mixture the feldspar produces a vitreous mass at 1,270° C., and at 1,350° only a very slight warpage occurs. The color is equal to the standard trial. The translucency when fired at 1,350° C. is 0.65 and the transmitted light is cream colored. Total shrinkage at 1,350° C. is 15 per cent, 3 per cent drying shrinkage and 12 per cent firing shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

SPEEDWELL POSTOFFICE. COX PROSPECT. MICROCLINE.

"This prospect is in a creek bed on the east face of Panther Knob 1 mile west of Speedwell postoffice, Jackson County, N. C. The nearest shipping point is Sylva, Jackson County, which is 10 miles north. The feldspathic material is a pegmatite dike which, from the surface indications, carries very little quartz and mica. Its strike is N. 55° E. The commercially valuable feldspathic material exposed has a width of about 6 feet. The sample taken shows a deformation temperature ranging from 1,300° to 1,325° C. When fused this feldspar is clear and free from tint.

Properties in standard porcelain mixture.

In the standard porcelain mixture this feldspar produces vitrification when fired to 1,300° C., and shows no warpage at 1,350.° Fired to 1,350° C., the color is equal to the standard trial, the translucency is 0.69, and the transmitted light is cream colored. The total shrinkage when worked plastic is 15.3 per cent. Under the raw-lead and fritted glazes the color is unaltered.

SPRUCE PINE. AMERICAN GEM AND PEARL COMPANY MINE. MICROCLINE.

"A pegmatite dike which has been worked for aquamarine, is one-half mile east of the Spruce Pine-Marion road and 3 miles southeast of Spruce Pine, Mitchell County, N. C., which is the nearest shipping point. The mine is on the slope of a low ridge and has been worked by an incline. In September, 1911, the workings were full of water and their inspection was impossible. Fine orthoclase of a very pale flesh tint predominates in the dump, and the reports of residents agree that the dike averages over 10 feet wide and consists principally of feldspar very free from mica, the chief associated materials being

beryl and a little quartz, which occur chiefly along the walls. The wall rock is reported to be solid and to require no timbering. The dike strikes northeast and dips 80° S.

"The deformation temperature range of the feldspar is 1,310° to 1,330° C. The feldspar fuses to a glass with little cloudiness and no yellow tint.

Properties in standard porcelain mixture.

In the mixture this feldspar when fired to 1,310° C. produces a vitreous mass which shows no warpage at 1,350°. The color is equal to the standard trial. Fired to 1,350° C., the translucency is 0.66 and the transmitted light is cream colored. The total shrinkage is 15.5 per cent, of which 3 per cent is drying shrinkage and 12.5 per cent firing shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

SPRUCE PINE. COOK MICA MINE. MICROCLINE.

"This mine is 2 miles west of Spruce Pine, Mitchell County, N. C. Open-cuts lie on the northeast face of a spur of Little Chalk Mountain 400 yards south of North Toe River; 200 yards to the south and 100 feet higher a cut and a short tunnel expose another pegmatite dike. The nearest shipping point is Spruce Pine, although the C. C. and O. Ry. follows the opposite bank of the North Toe River.

"These dikes strike N. 30° E. and dip 80° SE. The lower dike exposed is broad and shows a band of feldspar 12 feet wide in places and averaging 8 to 10 feet wide. The largest feldspar band is cream-white, but the other smaller bands are pink. There is one small band of albite, but it is separated from the potash feldspar; hence it will cause no trouble in mining. The mica is generally in the flinty bands that adjoin the walls.

"The upper dike, 6 to 9 feet wide, contains along the middle a band of feldspar averaging 4 feet wide. All wall rock appears solid. The country rock is gneiss. The cream-white feldspar band of the lower deposit has the following chemical composition:

Composition of cream-white feldspar band.

H_2O	0.40
SiO_2	64.93
Al_2O_3	19.45
Fe_2O_3	Trace.
TiO_2	Trace.
CaO	.05
MgO	Trace.
K_2O	12.46
Na_2O	2.54
	99.83

"The deformation temperature range of this feldspar is from 1,290° to 1,310° C. The feldspar fuses to a glass with only a trace of milkiness and no yellow tint.

Properties in standard porcelain mixture.

This feldspar in the mixture produces a vitreous mass at 1,300° C., and at 1,350° shows no evidence of warping. The color is equal or superior to the standard trials. When fired at 1,350° C. the translucency is 0.74 and the transmitted light is cream colored. The total shrinkage is 15.8 per cent, 3 per cent being drying and 12.8 per cent burning shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

SPRUCE PINE. ENGLISH KNOB MICA MINE. MICROCLINE.

"This mine is 2½ miles northeast of Spruce Pine, Mitchell County, N. C. The property has been worked for mica at various points along the strike of the dike for about 200 feet, the general strike being N. 40° E. This pegmatite seems to be of uniform quality and a large percentage of pure feldspar is found. The width of the feldspar band varies from 5 to 12 feet.

"At the present time the workings do not permit sampling at much depth. The surface material, however, indicates a good prospect.

SPRUCE PINE. WISEMAN MICA MINE. ALBITE AND ORTHOCLASE.

"This mine is near the head of Beaver Creek, 2 miles north of Spruce Pine, Mitchell County, N. C., which is the nearest shipping point.

"The tunnels on the southwest slope of the mountain have all caved but one. In this the dike strikes nearly west; the dip varies greatly. The feldspar-rich pegmatite averages not more than 4 feet wide where exposed, but it is low in quartz content and doubtless could be made marketable by some cobbing. Orthoclase is present in small isolated masses, but the greater portion of the dike is albite, of which the analysis follows:

Composition of albite.[1]

SiO_2	64.85
Al_2O_3	19.90
K_2O	2.91
Na_2O	10.04
	97.70

"This material has a deformation range of 1,290° to 1,295° C. and fuses to an opaque white mass.

[1]See North Carolina Geol. Surv. Economic Paper No. 6, pp. 49-50.

Properties in standard porcelain mixture.

In the mixture this feldspar produces vitrification at 1,295° C., and at 1,330° produces slight warping. The color is slightly bluish when compared with a standard white porcelain trial. When fired at 1,350° C. the translucency is 0.62 and the transmitted light is cream colored. The total shrinkage is 15.4 per cent, of which 3 per cent is drying shrinkage and 12.4 per cent firing shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

GRANITE.

"Throughout Mitchell County there are vast areas of coarse granite that contain a high percentage of feldspar. There is always some small mica, but not sufficient to justify mining. There are outcrops in the Spruce Pine-Marion road just south of Spruce Pine and (100) on the face of Big Chalk Mountain just west of Spruce Pine. The granite generally occurs as sills and appears very free from any impurities except the quartz and mica. The general strike is west.

Samples of this granitic material show the following chemical composition:

Composition of granitic material.

H_2O	0.90
SiO_2	75.10
Al_2O_3	15.57
Fe_2O_3	.47
TiO_2	.03
CaO	1.10
MgO	Trace.
K_2O	3.49
Na_2O	2.86
	99.52

"This material has a deformation temperature range from 1,300° to 1,315° C. The micaceous material present is too high in iron and imparts to the pulverized granite when fused a pronounced cream-yellow tint.

Properties in standard porcelain mixture.

This material does not produce vitrification in the mixture until 1,310° C. is reached; at 1,350° warping is detected. The color of the porcelain produced is cream. The translucency when fired at 1,350° C. is 0.62 and the transmitted light is cream-yellow. The total shrinkage is 13.6 per cent, 4.4 per cent drying and 9.2 per cent firing shrinkage. Under the raw-lead and fritted glazes the color is unaltered.

SEMIKAOLINIZED FELDSPAR MINES AND PROSPECTS.

BAKERSVILLE. FLUKIN RIDGE MICA MINES.

"These mines are on a ridge 2½ miles south of Bakersville, Mitchell County, N. C., and one-half mile west of the Bakersville-Ledger road. The nearest shipping point is Toecane, 3½ miles northwest. This ridge contains a large number of dikes of partly decomposed pegmatite, which strike N. 50° E., dip 65° S. Some of these dikes contain a large amount of fine quartz, but others contain very little quartz. No large masses of quartz are exposed in any of the workings. Tunnels and shafts have been dug over an area one-half mile long and one-eighth mile wide and more or less of this semikaolinized material (locally called 'flukin') is found in every case.

"This material has altered so that it may be crushed to sand with the hand. A dike free from quartz was sampled and analyzed; it showed the following composition:

Composition of semikaolinized feldspar.

H_2O	1.34
SiO_2	63.32
Al_2O_3	20.45
Fe_2O_3	.07
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
K_2O	14.20
Na_2O	.80
	100.18

"Calculated from the analysis, the mineral composition of this material is as follows:

Mineral composition of semikaolinized feldspar.

Microcline	84.0
Albite	6.8
Kaolinite	9.02
	100.0

"The deformation temperature range of this material is from 1,330° to 1,350° C. The fused material is almost clear, but has a slight gray tint.

Properties in standard porcelain mixture.

Introduced on the basis of its calculated mineral constitution, this material gives a vitreous mass at 1,330° C. The color is slightly gray by comparison with a standard trial. Fired at 1,350° C. the material has a translucency of 0.70 and the transmitted light is cream colored. The total shrinkage is 15.4 per cent, 3 per cent being drying and 12.4 per cent firing shrinkage. Fired under the raw-lead and fritted glazes this mass has the same faint grayish tint.

BEAVER CREEK. SOUTH HARDIN MICA MINE.

"This mine, which is described under 'Kaolins,' is 1½ miles southwest of Beaver Creek, Ashe County, N. C. The dike was found to contain, where exposed, only semikaolinized feldspathic materials, which seem to be of very nearly uniform quality. The entire width of the dike was sampled and analyzed; it showed the following composition:

Composition of semikaolinized feldspar.

H_2O	7.30
SiO_2	53.00
Al_2O_3	29.20
Fe_2O_3	.21
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
BaO	.00
K_2O	9.92
Na_2O	.53
	100.16

"The mine at the present time is so far from the railroad and the percentage of alkali in the sample taken is so low that the present availability of the material as a substitute for feldspathic material is doubtful. The color, however, appears to be sufficiently good for this purpose. If lower levels should show considerable quantities of semikaolinized material, it doubtless will some day be available as a flux material for pottery. On the other hand, if the dike lower levels prove to be completely altered, as in certain sections which were exposed by the owners but are now closed by caving, the dike may become a source of kaolin.

BRYSON. HARRIS CLAY COMPANY MINE.

"This mine is 2 miles north of Bryson, Swain County, N. C. The dikes from which the kaolin has been obtained are not uniform in degree of kaolinization. Many sections of these dikes are only slightly

kaolinized and at a few points fresh feldspar is found. A large amount of this semikaolinized material can be obtained from this mine. This material was sampled and analyzed; it showed the following chemical composition:

Composition of semikaolinized feldspar.

H_2O	0.94
SiO_2	63.60
Al_2O_3	20.40
Fe_2O_3	.32
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
BaO	.00
K_2O	14.40
Na_2O	.50
	100.16

"The deformation temperature range is from 1,330° to 1,350° C., and the material fuses to a slightly milky mass free from yellow tint.

"From the above chemical analysis this material is calculated to have the following mineral composition:

Mineral composition of semikaolinized feldspar.

Orthoclase	85.4
Albite	4.2
Kaolinite	9.4
Quartz	1.0
	100.0

Properties in standard porcelain mixture.

Introduced on the basis of its calculated mineral constitution, this material gives a vitreous mass at 1,350° C. and the color is equal to the standard trial. Fired at 1,350° C. the translucency is 0.70 and the transmitted light is cream colored. The total shrinkage is 15.6 per cent, of which 3 per cent is drying and 12.6 per cent is firing shrinkage. Tested under the raw-lead and fritted glazes this porcelain showed no change in tint.

FALLSTON. FRANK BAXTER MICA MINE.

"This mine is 13 miles northeast of Shelby and 3 miles southeast of Fallston, Cleveland County, N. C., and 1 mile north of the Thomas Baxter mica mine. It is in a semikaolinized pegmatite dike, as indicated by the dumps, but the workings have fallen in and little idea of the extent of the dike can be obtained. The general strike of the dike as indicated by the shafts is northeast.

"A quantity of this semikaolinized material, exposed in one shaft about 12 feet deep, was sampled and tested. It has a combined-water content of 12.4 per cent and when fired to 1,330° C. shrinks 15 per cent. Its refractory value is 1,670° C.

FRANKLIN. GURNEY CLAY COMPANY MINE.

"This mine is 4 miles north of Franklin, Macon County, N. C. The semikaolinized feldspar is exposed by an old tunnel for mica 250 feet southwest of the present workings for kaolin. The material occurs as a lens and has a general north strike. The material is pure white, and resembles kaolin, but possesses a bonelike texture and no plasticity. It contains 13.1 per cent of combined water and has a refractory value of about 1,700° C.

"This material is too low in water to be halloysite and hence must be classed as kaolinite.

FRANKLIN. MOORE MICA MINE.

"This mine is 1½ miles north of Franklin, Macon County, N. C., on the west bank of the Little Tennessee River.

"The dike, which is more or less kaolinized, averages about 9 feet thick; it has a general northeast strike and dips almost vertically. The overburden averages about 25 feet thick. The dike is very free from associated minerals and no large quartz bands are exposed. A portion of this dike is completely kaolinized, but large amounts of the feldspar are only slightly altered. A sample of slightly altered material showed the following chemical composition:

Composition of semikaolinized feldspar.

H_2O	2.05
SiO_2	63.74
Al_2O_3	20.90
Fe_2O_3	.12
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
BaO	1.10
K_2O	11.70
Na_2O	.19
	99.80

"The mineral composition calculated from this analysis is as follows:

Mineral composition of semikaolinized feldspar.

Microcline	72.0
Albite	1.7
Kaolinite	17.6
Quartz	8.7
	100.0

"The deformation temperature range of this material is from 1,350° to 1,370° C. The material fuses to a slightly milky glass with no yellow tint.

Properties in standard porcelain mixture.

Introduced on the basis of its calculated mineral constitution, the material gives a vitreous mass at 1,350° C.; its color is equal to the standard trial. Fired at 1,250° C. the translucency is 0.68 and the transmitted light is cream colored. The total shrinkage is 15.6 per cent, of which 3 per cent is drying and 12.6 per cent is firing shrinkage. Tested under the raw-lead and fritted glazes this porcelain shows no change of tint.

FRANKLIN. SOUTHERN CLAY COMPANY MINE.

"This mine was worked entirely for kaolin, but throughout the dike lenses of semikaolinized material were found. At the upper levels the semikaolinized material is loose and very light. It has a combined-water content of 8.65 per cent and deforms at 1,590° C., although it is translucent at 1,350° C.

"These lenses are hardly large enough to be of industrial importance.

"Where mining has reached a depth of about 80 feet the dike is only partly kaolinized, and at greater depths the kaolinization decreases until material approaching feldspar in appearance and composition is found:

"This slightly kaolinized feldspar was sampled. Analysis showed it to have the following chemical composition:

Composition of semikaolinized feldspar.

H_2O	1.40
SiO_2	62.47
Al_2O_3	21.00
Fe_2O_3	.05
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
BaO	.30
K_2O	13.62
Na_2O	.60
	99.44

"The mineral composition of this material is calculated as follows:

Mineral composition of semikaolinized feldspar.

Orthoclase	82.0
Albite	5.0
Kaolinite	8.0
Quartz	5.0
	100.0

"The semikaolinized feldspar has a deformation temperature range from 1,350° to 1,370° C. It fuses to a glass only slightly milky and free from yellow tint.

Properties in standard porcelain mixture.

Introduced on the basis of its calculated mineral constitution, this material gives a vitreous mass at 1,350° C., and its color is equal or superior to the standard trial. Fired at 1,350° the translucency is 0.70 and the transmitted light is cream colored. The total shrinkage is 15.5 per cent, of which 3 per cent is drying and 12.5 per cent is firing shrinkage. Tested under the fritted and raw-lead glazes this porcelain shows no change in tint.

"In order to determine the effect of washing, a quantity of the material was subjected to the standard laboratory washing process. The residue having a hydraulic value of more than 0.17 was analyzed and found to have the following chemical composition:

Composition of residue of hydraulic value more than 0.17.

H_2O	0.40
SiO_2	63.21
Al_2O_3	21.08
Fe_2O_3	.08
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
BaO	.30
K_2O	14.03
Na_2O	.60
	99.70

"The material is thus seen to have lost a part of its kaolinite, thus lowering its deformation temperature. This is further shown by firing since the washed material has a deformation temperature range from 1,340° to 1,360° C.

MARSHALL. SETH FREEMAN PROSPECT.

"This prospect is at the junction of Bear Creek and Marshall roads, on Trail Branch of Sandy-Mush Creek, 4 miles south of Marshall, Madison County, N. C., which is the nearest shipping point.

"This dike is about 100 feet wide, but with many intruded horses of wall rock, so that few bands occur more than 8 feet thick. The strike is N. 40° E. and the dip 20° SE. The material sampled has the appearance of a fine white sand. It was found to have the following chemical composition:

Composition of semikaolinized feldspar.

H_2O	5.42
SiO_2	65.05
Al_2O_3	22.39
Fe_2O_3	.29
TiO_2	.12
CaO	Trace.
MgO	Trace.
BaO	.30
K_2O	6.53
Na_2O	.21
	100.31

"From the chemical analysis this material is calculated as having the following mineral composition:

Mineral composition of semikaolinized feldspar.

Microcline	39.50
Albite	1.80
Kaolinite	37.10
Quartz	21.60
	100.00

"Its deformation temperature range is 1,450° to 1,470° C., and it fuses to a slightly milky glass, with a faint yellow tint.

Properties in the standard porcelain mixture.

Introduced on the basis of its calculated mineral constitution, this material gives a vitreous mass at 1,350° C., and the color of the mass shows no trace of the yellow tint noted in the fused material, but is fully equal to the standard trial. Fired at 1,350° C. the translucency is 0.68 and the transmitted light is cream colored. The total shrinkage is 15.4 per cent, 3 per cent being drying and 12.4 per cent firing shrinkage. Tested under the raw-lead and fritted glazes this porcelain showed no change in tint.

MONTVALE. REED MICA MINE.

"This mine is 2½ miles southeast of Sapphire and 1 mile northeast of Montvale, Jackson County, N. C.

"It is in a dike of slightly kaolinized feldspar about 5 feet thick, but carrying a 2-foot quartz band in the middle. The dike strikes N. 25° E. and dips 40° NW. The feldspathic material is friable, but retains its crystalline structure.

"The feldspathic portion of the dike contains 2 per cent of combined water. The deformation temperature range of the material is from 1,355° to 1,370° C. The material becomes a semiopaque mass on fusing.

Properties in the standard porcelain mixture.

This material, tested on a basis of 85 per cent feldspar, 10 per cent kaolinite, and 5 per cent quartz, produces a vitreous porcelain at 1,330° C. The color is cream white. The material has translucency of 0.64 when fired at 1,350° C. The total shrinkage is 15.7 per cent, of which 3 per cent is drying and 12.7 per cent is firing shrinkage. No increase in color intensity is noted under the raw-lead or fritted glazes.

RUTHERFORDTON. ISINGLASS HILL MICA MINE.

"This mine is on a low ridge 3 miles north of Rutherfordton, Rutherford County, N. C., adjoining the line of the Southern Railway. There are no shipping facilities nearer than Rutherfordton, however.

"This pegmatite dike varies from 6 to 50 feet in diameter and is nearly one-fourth mile long. The general strike of the deposit is N. 20° E. and the dip is 80° to 85° W.

"This dike is bisected by a quartz band 1 to 3 feet wide. The portion west of this quartz band is practically pure kaolin, whereas the portion east of it is semikaolinized material. The associated minerals of this dike are a few scattered iron garnets and numerous nodules of wad. The mica is found adjoining the walls, is generally solid, and could be easily removed.

"This semikaolinized material was sampled and analyzed; it has the following composition:

Composition of semikaolinized feldspar.

H_2O	3.60
SiO_2	60.47
Al_2O_3	23.45
Fe_2O_3	.10
TiO_2	Trace.
CaO	Trace.

MgO	Trace.
K_2O	12.10
Na_2O	.65
	100.37

"From this analysis the mineral composition of the material has been calculated to be as follows:

Mineral composition of semikaolinized feldspar.

Orthoclase	71.5
Albite	5.5
Kaolinite	23.0
	100.0

"This material has a deformation temperature ranging from 1,350° to 1,390° C., and fuses to a semiopaque glass with no yellow tint.

Properties in the standard porcelain mixture.

Introduced on the basis of its calculated mineral constitution, this mineral gives a vitreous mass at 1,330° C. The color is fully equal to the standard trial. Fired at 1,350° C. the translucency is 0.70 and the transmitted light is cream colored. The total shrinkage is 15.5 per cent, 3.2 per cent drying and 12.3 per cent firing shrinkage. Fired under the fritted and raw-lead glazes this mass is unchanged in tint.

SYLVA. FOREST HILL MICA MINES.

"These mines are 10 miles south of Sylva and 1 mile west of Cullowhee Creek in Jackson County, N. C. The nearest shipping point is Sylva. The mines are in a semikaolinized pegmatite dike situated along the northeast slope of a spur of Panther Knob. This dike is extensive; it has been crosscut for more than 30 feet, and tunnels along the strike have been run for more than 100 yards. The dike material is largely feldspar in various stages of decomposition. A large part, however, is only slightly kaolinized and retains the characteristic orthoclase structure and cleavage and its alteration is evidenced only by its friability, it being readily crushed with the fingers. It is pure white in color and is entirely devoid of plasticity, even when pulverized. A quantity of this material was sampled and by chemical analysis found to possess the following composition:

Composition of semikaolinized feldspar.

H_2O	0.90
SiO_2	63.35
Al_2O_3	20.07

Fe_2O_3	.15
TiO_2	Trace.
CaO	.03
MgO	Trace.
K_2O	13.70
Na_2O	1.11
	99.31

"This material so closely resembles feldspar that it can be utilized as a flux for fine porcelain. Its mineral composition is, approximately, as follows:

Mineral composition of semikaolinized feldspar.

Orthoclase	81.8
Albite	9.5
Kaolinite	8.2
Quartz	.5
	100.0

"The deformation temperature ranges from 1,310° to 1,340° C. When fused the material is free from yellow tint and only very slightly milky.

Properties in the standard porcelain mixture.

When introduced into the mixture in proportions based upon its mineral constitution this material produces a vitreous mass at 1,330° C. The color is equal or superior to the standard trial. The translucency is 0.74 and the transmitted light is cream-white. The total shrinkage is 15.2 per cent, 3 per cent being drying and 12.2 per cent firing shrinkage. No change in color is noted under the raw-lead or fritted glazes.

"Another section of this dike shows material more kaolinized. This material contains 6.96 per cent combined water, and has a deformation temperature of 1,510° C.; hence it could be used only in a limited way to replace feldspar as an alkali-bearing material in the porcelain mass. Its color is pure white. By calcination the combined water may be removed, producing a material of low shrinkage. (See also feldspar and kaolin under this name.)

TOECANE. BENNER MICA MINE.

"This mine is on the south slope of Sink-Hole Ridge and one-half mile west of Flukin Ridge, Mitchell County, N. C. The nearest shipping point is Toecane, which is 4 miles northwest.

"The kaolinized pegmatite dike is broad. Some of it is completely altered to a high-grade kaolin, and a large part apparently lacks only

the plasticity to make it perfect kaolin. Very little fine quartz and no large quartz is found in this dike. The strike is N. 60° E. and the dip 75° S. There are four shafts and a tunnel besides numerous pits.

"This nonplastic kaolin was sampled and tested. It contains 11.3 per cent combined water, and has a refractory value greater than 1,700° C. When fired alone at 1,330° C. it has a total shrinkage of 15.25 per cent, 3 per cent drying and 12.25 per cent firing shrinkage. Color is pure white, free from specks. The raw-lead and fritted glazes make no changes in the tint of the mass.

BAKERSVILLE. HAWK MICA MINE.

"The Hawk mica mine is about 3 miles east of Bakersville, Mitchell County, N. C. Operations were by tunnels, and most of these are now caved and closed. Two tunnels on the south side of the hill show a small dike of semikaolinized feldspar that is much stained by associated iron-bearing clays, but doubtless would be less stained at greater depth. No fresh feldspar or kaolin is exposed in either tunnel.

TULIP POSTOFFICE. HOLE MICA MINE.

"This mine is on a ridge above Dan River near Tulip, Stokes County, N. C., 16 miles southwest of Stuart, Patrick County, Va., which is the nearest shipping point.

"The semikaolinized pegmatite dike nearly 25 feet thick strikes west and dips 30° N. Three bands of quartz, each more than 4 feet thick, occur in this dike, and apparently lie along the walls and midway between. Another band of pegmatite is said to occur below the lowest exposed quartz band, but the opening that exposed it has been refilled. Between these massive quartz bands are numerous pegmatite bands of varying quartz content and some of these narrow bands are much iron-stained, making mining difficult if this stained material must be eliminated.

"The two exposed bands of semikaolinized pegmatite were sampled and found to contain 13 per cent and 13.2 per cent, respectively, of combined water. Fired to 1,330° C. the material shrinks 15 to 15.3 per cent and becomes a pale-cream color. Its refractory value is above 1,700° C.

KAOLIN MINES AND PROSPECTS.

ALMOND. HEWITT MINE.

"This mine is 3½ miles south of Almond, in Swain County, N. C., and one-half mile west of the Little Tennessee River. Four exposures

have been operated on this property. The last opening operated is a dike which runs north and dips 75° E. It is an impure granite-pegmatite, incompletely kaolinized. The bands are not well defined and the whole mass has reached a state comparable only with sand. In places the overburden has been removed and the dike worked as an open-cut. The dike varies from 20 to 30 feet thick and has been removed for 275 feet into the hill to a depth of 40 to 60 feet. The dike is on a ridge. The material has been removed in dump cars to a steep slope in the hill down which it has been dumped into a stock bin and from this has been removed as required to a field washing plant near by. This washing plant, operated by a 20-horse-power portable engine, consists of two ordinary clay washers and two sand wheels through which the crushed kaolin passes to mica-settling troughs. After passing the mica troughs the kaolin is conveyed by flume to the concentrating plant, which is one-half mile distant on the west bank of the Little Tennessee River. This plant comprises concentrating tanks and a press equipment, including cistern, pumps, and two standard filter presses.

"From the presses the kaolin goes to three open-air drying sheds, averaging 100 by 14 feet.

"Kaolin from this mine was sampled directly from the dike, and by the laboratory process shows a kaolin content of 20 per cent.

"The kaolin has a refractory value of 1,650° C. In color it falls very slightly below the scale established, and for that reason has been called grade 6. The shrinkage in drying at 110° C. is 3.6 per cent and in firing at 1,350°, 8.7 per cent. When dried at 110° C. the kaolin has a tensile strength of 6 pounds per square inch.

Properties in standard porcelain mixture.

In the mixture fired at 1,350° C. this kaolin gives a translucency of 0.66 and the transmitted light is yellow. Absorption is 1.9 per cent. The color is grade 6. The shrinkage when dried at 110° C. is 2 per cent; when fired at 1,350° C., 13.2 per cent. The color is not affected by the application of either the raw-lead or the fritted glazes.

ALMOND. HYDE PROSPECT.

"This prospect is in Swain County, N. C., 2 miles east of Almond, on the east side of the Little Tennessee River. The deposit opened is an expanded lens covering practically the whole of a ridge 1½ to 2 acres in area. It is opened by five test holes and two tunnels, at an average elevation of 200 feet above the river, on both sides of the ridge, which has a direction N. 20° E. The lens is very irregular and possesses no

uniform dip. The best exposure on this property was in the tunnels, one having a length of 75 feet and exposing a clear width of dike material of only 20 feet. This tunnel was sampled from a point 30 feet from the entrance to the end, a distance of 45 feet. The material at the end is 60 feet below the crest of the ridge.

"The material collected was washed by the standard laboratory process and yielded only 19 per cent of kaolin. This kaolin was tested. It has a refractory value of 1,670° C. The color is grade 6. Dried at 110° C. the kaolin shrinks 4.2 per cent and fired at 1,350° C., 8.8 per cent. The tensile strength is 8 pounds per square inch.

Properties in standard porcelain mixture.

In the mixture and fired at 1,350° C. this kaolin gives a translucency of 0.64 and the transmitted light is yellow. Absorption is 2.2 per cent. The color is grade 6. The shrinkage when dried at 110° C. is 2.1 per cent, and when fired at 1,350° C., 12.8 per cent. Tested under the raw-lead and fritted glazes the color is unaffected.

ALMOND. MESSER PROSPECT.

"This prospect is 2½ miles south of Almond, Swain County, N. C., on the west side of the Little Tennessee River. Two tunnels on opposite sides of the knoll and 25 feet below the crest expose a kaolin deposit running across the knoll. The dike appears to have a north strike and the dip where exposed is vertical. The material in these tunnels contains a fair quality of kaolin, but the dike contains a great many narrow streaks of stained material which greatly reduce the value of the deposit at this point. The openings are 200 feet above Little Tennessee River, and undoubtedly the dike at a lower point would show material of a much higher grade.

ASHEVILLE. SNIDER PROSPECT.

"This prospect is on a small tract of land 3½ miles west of Asheville, N. C., on the Asheville-Alexander road. It is on the north bank of French Broad River and is 550 yards north of the Southern Railway, which here follows the river. The dike has a total width of 8 to 10 feet where exposed, but contains a number of horses of wall rock. This exposure, however, goes only 16 feet below the surface and cannot indicate the dike structure at lower levels. The dike strikes N. 30° E. and dips 75° SE. The material is somewhat sandy and carries a large amount of white mica, most of which is in very small particles, has a bright luster, and is an ideal material for the pulverized-mica industry. Similar dikes along the general strike of this one are exposed

for half a mile, but only by small pits, and no statement as to the quality of their material is attempted. The occurrence of a considerable deposit of dikelike formation 1 mile distant was noted, but found to contain a bluish-white sand similar to the deposits in the neighborhood of Almond, Swain County, N. C. The material in the Snider prospect was sampled and yielded 24 per cent of kaolin and 9 per cent of white mica.

"The kaolin showed under test a refractory value of above 1,730° C. Its color is grade 3. The shrinkage when dried at 110° C. is 4.2 per cent and fired at 1,350° 14 per cent. The tensile strength of this kaolin is 24 pounds per square inch.

Properties in standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. this kaolin gives a translucency of 0.67 and the transmitted light is cream colored. Absorption is 4.8 per cent. The color is grade 3. The shrinkage when dried at 110° C. is 3 per cent and fired at 1,350° C. 12.8 per cent. Tested under the raw-lead and fritted glazes the color remains unaltered.

BAKERSVILLE. AMERICAN MICA AND MINING COMPANY MINE.

"This mine is in an isolated lens of kaolin on the brow of the hill 1 mile south of Bakersville, Mitchell County, N. C. The dike strikes northeast and shows a width of about 12 feet of good-quality kaolin. Attempts, however, to prove the extent of this material in either direction have failed. The deposit is doubtless an expanded lens of kaolinized material belonging to a dike that is exposed 300 yards to the southwest by a shaft on this same property and there shows 5 to 6 feet of kaolin.

"A careful attempt to locate the dike at intermediate points by borings made at 3-foot intervals failed to expose any dike material, and it is therefore concluded that the dike between these points must be very narrow.

BAKERSVILLE. BENNER MICA MINE.

"This mine is on the south face of Sink Hole Ridge, 3 miles southeast of Bakersville, Mitchell County, N. C. The greater part of the dike where exposed on this property is semikaolinized material. The northwest part of the dike, however, appears to be isolated by a broad band of wall rock from the rest of the dike, and into this part four shafts have been sunk along the strike. These shafts have been abandoned and at the time of inspection no means was available for getting to the bottom of them.

"The material removed from this part of the dike, as indicated by the dumps, is a good plastic kaolin. The width of this kaolin, however, is reported by men who worked in the mine as very narrow, at some places not exceeding a few feet. The length of the exposure developed by the shafts is reported to be only a few rods. Inability to inspect the dike prevented a more complete report.

BAKERSVILLE. THOMAS HOWELL PROSPECT.

"This prospect is on Flukin Ridge 2½ miles south of Bakersville, Mitchell County, N. C., and west of the Bakersville-Spruce Pine road. This prospect was also sampled for semikaolinized feldspar. (See p. 233.) At one point a considerable quantity of fine white kaolin is encountered. There are, however, occasional streaks of fresh feldspar and on all sides of the lens there is semikaolinized material; these facts justify the assumption that the kaolin is merely an isolated lens and would not justify the equipment of an extensive outfit for handling it, although the presence in the neighborhood of other isolated kaolin deposits would justify the sinking of shafts and the removal of this kaolin to a central washing plant, if one were provided.

BAKERSVILLE. AARON M'KINNEY PROSPECT.

"This prospect is 1 mile northeast of Bakersville, Mitchell County, N. C., and 3 miles from Toecane, the nearest railroad point.

"The dike is about 30 feet wide, including two horses of mica gneiss averaging between 6 and 8 feet thick where exposed. The dike occurs along a ridge and has been proven for about 300 yards. Its strike is northeast and its dip is nearly vertical. The pegmatite of the dike is almost completely kaolinized and contains numerous small pockets of micaceous material heavily stained with iron. The removal of these pockets without contamination of the white kaolin would demand much care in mining. This dike has been opened by two tunnels along and one across the dike, besides a number of test holes. The kaolin material in this dike was sampled; by a laboratory washing process it yielded 32 per cent of kaolin.

"This kaolin has a refractory value above 1,730° C. and its color is grade 2. When dried at 110° C. it shrinks 4.4 per cent and when fired at 1,350° C., 12.9 per cent. The tensile strength of this kaolin dried at 110° C. is 28 pounds per square inch.

Properties in standard porcelain mixture.

This material in the mixture when fired at 1,350° C. has a translucency of 0.61 and the transmitted light is cream colored. Absorption is 4.25 per cent. The color is grade 2. Dried at 110° C. the shrinkage of the kaolin is 2.8 per cent, fired at 1,350° C. it is 10.6 per cent. Tested under the raw-lead and fritted glazes this mass shows a pronounced green tint, equally apparent under both glazes.

BAKERSVILLE. JOHNSON M'KINNEY MICA MINE.

"This mine is 1 mile northeast of Bakersville, Mitchell County, N. C., and is a continuation of the Aaron M'Kinney prospect situated due southwest. This mine has been worked more or less for mica, but the operations have been entirely by shaft and the openings have all been allowed to fill with refuse, making a sampling of this mine impossible without great expense.

BAKERSVILLE. SINK-HOLE RIDGE PROSPECT.

"This prospect consists of irregular dikes, doubtless expanded lenses, occurring in what is known as the Sink Hole, a ridge with a sunken crest, about 3 miles southeast of Bakersville, Mitchell County, N. C., and about 3 miles from Toecane, the nearest railroad station. The property has been thoroughly mined for mica and the more or less kaolinized material in the various dikes has been so mixed with wall rock and other impurities that the opening of a kaolin mine would be almost impossible. The depth of mining in some places reached 40 feet and in others did not exceed 30 feet. The material found is invariably more or less kaolinized, but the larger part is high quality as regards color. The present workings are all in a semikaolinized part of the dike and the abandoned workings are completely closed by refuse from the later workings. Consequently this statement on the composition of the dike materials at different points is based on examination of the dumps. The inability to obtain material directly from the dike made further investigation unadvisable.

BEAVER CREEK. SOUTH HARDIN MICA MINE.

"This mine is 1½ miles southwest of Beaver Creek, Ashe County, N. C. The pegmatite dike is 6 to 10 feet wide, strikes N. 40° E., and dips 60° SE. It has been exposed by open-cuts and shafts and one tunnel following the strike. The material is kaolinized to a very uniform extent wherever exposed, but in no exposures has kaolinization proceeded far enough to cause the development of plasticity, although it is reported that in old shafts now entirely closed by slides a good grade

of plastic kaolin was exposed. However, the dike material which was carefully sampled fails entirely to fall under the kaolin classification, and it is therefore reported as semikaolinized feldspar.

BETA. LOVE PROSPECT.

"This prospect is 1 mile east of Beta, Jackson County, N. C., on the north side of the Murphy Branch of the Southern Railway. This prospect is opened on a low isolated hill adjoining the railway and as the test holes are now almost completely filled with refuse, no idea of the extent of the deposit can be obtained. However, the dumps from these holes indicate that kaolin of fair quality occurs here.

BOONFORD. YOUNG PROSPECT.

"This prospect is 1 mile west of Boonford, Yancey County, N. C. The dike averages about 30 feet in width and contains a 4-foot horse of wall rock in the middle. It strikes northeast and dips 85° S. The material in the deposit adjoining the northwest wall and on the north side of the band of wall rock is very much more advanced in kaolinization than is the material on the southeast side of this band. The entire dike is free from impurities except for a very small amount of garnet sand occurring in small pockets. This dike has been proven for only a short distance, but the surface indications are that it is partly exposed several yards distant along the strike in both directions. However, the topography is so irregular that a thorough proving by test holes and tunnels, if necessary, would alone settle this point.

"Material from this dike, where exposed by tunnel, was sampled. By the laboratory washing process this material yielded 22 per cent of kaolin having a refractory value above 1,730° C. and a color of grade 2. When fired at 1,350° C. the shrinkage of this kaolin is 12.6 per cent; dried at 110° C. the shrinkage is 4.8 per cent. This kaolin dried at 110° C. has a tensile strength of 22 pounds per square inch.

Properties in standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. this kaolin shows a translucency of 0.76 and the transmitted light is cream colored; absorption is 6 per cent. The color is grade 2 and the shrinkage when dried at 110° is 4 per cent, and fired at 1,350° C., 12.4 per cent. When tested under the raw-lead and fritted glazes no change of tint is apparent in this mass.

BRYSON. CAROLINA CLAY COMPANY MINE.

"This mine is at the head of Buckner Branch, 4 miles southwest of Bryson, Swain County, N. C. It is reported as having been entirely worked out, but continuations of the dike or similar dikes occur both to

the north and south of this worked deposit. The dike is about 16 feet wide. It strikes N. 15° E., and dips about 75° W. It is rich in kaolin along the west wall, but becomes progressively poorer toward the east wall, along which the dike material is practically all sand. Numerous pockets of garnet-colored sand and bands of the wall rock are noted.

"The clay-washing plant erected for use in connection with this mine has fallen into decay, but there is doubtless considerable valuable material still at this mine, and certainly on adjoining prospects, which could be washed from this plant.

"A sample of the dike material from across the full width of the dike yielded by the laboratory washing process 22 per cent of kaolin. This kaolin was tested and found to have a refractory value of 1,650° C. Its color is grade 5 and shrinkage 3.8 per cent when dried at 110° C., and 10.2 per cent when fired at 1,350° C. The tensile strength is 8 pounds per square inch.

Properties in the standard porcelain mixture.

In the mixture fired at 1,350° C. this kaolin has a translucency of 0.65 and the transmitted light is yellow. Absorption is 2.2 per cent. The color is grade 5. When the material is dried at 110° C. the shrinkage is 2.4 per cent, when fired at 1,350° C. it is 13.5 per cent. Tested under the raw-lead and fritted glazes the color remains unaltered.

BRYSON. EVERETT PROSPECT.

"This prospect is on a ridge above Watkins Branch, one-half mile east of the main road and 2 miles northwest of Bryson, Swain County, N. C. The width of the dike could not be determined positively, but from surface indications it is 9 to 10 feet wide. The prospect is due southwest from the Harris Clay Co. mine, and 1½ miles distant. The dike contains very few large flint bowlders, but a considerable proportion of semikaolinized material. The deposit was sampled as thoroughly as possible, and the material collected, when washed by the standard laboratory process, yields 28 per cent kaolin. The refractory value of this kaolin is above 1,730° C. Its color is grade 3; its shrinkage when dried at 110° C. is 4.3 per cent, fired at 1,350° C. 12.6 per cent. The tensile strength is 15 pounds per square inch.

Properties in standard porcelain mixture.

In the mixture fired at 1,350° C. this kaolin has a translucency of 0.65 and the transmitted light is cream colored. Absorption is 4.7 per cent. The color is grade 3. Dried at 110° C. the shrinkage is 3 per cent, fired at 1,350° C. it is 12.2 per cent. Tested under the raw-lead and fritted glazes the color remains unaltered.

BRYSON. HARRIS CLAY COMPANY MINE.

"This mine is on the east slope of a ridge 2 miles north of Bryson, Swain County, N. C. The dike varies from 40 to 60 feet wide, but contains many bands of the material that forms the wall rock. The dike, which is faulted at intervals of about 150 feet, strikes N. 20° E. Its average of flint content is low, but it varies considerably in degree of kaolinization, so that the kaolin content obtained by washing the material of this deposit is less than might reasonably be expected. In many parts of the dike the material is yellow and of low grade in color; spurs of the dike at the same points, however, are of pure material, free from stain. The dike has been practically worked out over the area within which the material was found to contain a commercial quality of kaolin. A similar dike was opened 1 mile southwest, but was abandoned after a few months' work. Good material has been located 3 miles northeast of the Harris mine. Mining was by open-cuts to a depth of about 35 feet and by shafts below. The overburden is handled with wheelbarrows and dump carts, and its removal has been a simple problem because the dike is along the face of a very steep ridge. The kaolinized material was handled in steel hopper cars, by which it was taken to the edge of the slope, where it was emptied into the cars of a gravity railway, by which it was carried a distance of 200 yards down the mountain and there automatically dumped into the storage bins. From these bins it was shoveled by hand into a flume, which was supplied with water from a brook near by. This flume carries the material one-half mile to the washing plant, where the regular system of washers and sand wheels is used to remove the coarse material. The fine material passes to a sand-settling trough and thence to the mica-settling troughs and over a battery of screens into another flume. The washed material, practically pure kaolin, is conveyed 1½ miles to the concentrating plant, which is in the valley. This concentrating plant consists of concentrating tanks and a battery of two filter presses. The pressed kaolin is dried in open-air sheds and is then ready for market.

"Samples of the material as mined were taken from the part of the dike being worked in the autumn of 1911. This material washed by the standard laboratory process yields 22 per cent of kaolin. This kaolin was analyzed and found to have the following chemical composition:

Composition of kaolin.

H_2O	14.10
SiO_2	46.95
Al_2O_3	37.24
Fe_2O_3	.40

TiO_2	.05
CaO	Trace.
MgO	Trace.
Na_2O	.24
K_2O	.49
	99.47

"The refractory value of this kaolin is above 1,730° C. The color is grade 3. Dried at 110° C. it shrinks 4 per cent, fired at 1,350° C. 12.8 per cent. The tensile strength is 14 pounds per square inch.

Properties in standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. this kaolin has a translucency of 0.63; the transmitted light is cream colored. Absorption is 3.3 per cent. The color is grade 3. Dried at 110° C. the shrinkage is 2.8 per cent, fired at 1,350° C. 11.8 per cent. Tested under the raw-lead and fritted glazes the color is unaffected.

BURNSVILLE. KAOLIN OUTCROPS.

One-half mile north of Burnsville, Yancey County, N. C., a small kaolinized dike that is exposed near the road has been worked in a small way for mica. The exposure is not large enough to justify any statement as to the kaolin content.

"Two and a half miles east of Burnsville on the road to Micaville is an old mica mine. Although the shaft is closed by caving, the material above the mouth of the shaft shows considerable semikaolinized feldspar and some kaolin.

BURNSVILLE. ELIZABETH SMITH MICA MINE.

"This mine is 1½ miles east of Burnsville, Yancey County, N. C., on the north side of and 150 yards distant from the Burnsville-Micaville road, and 3½ miles west of Micaville, the nearest shipping point. The dike is from 25 to 35 feet in width, strikes N. 20° E., and has an irregular dip. The deposit contains a number of semikaolinized lenses, but for the most part is well advanced in kaolinization. Of the mine tunnels some have been driven to expose kaolin and others in a search for mica. Those for mica have been neglected and in most instances have fallen in. On the southwest end of the dike are two tunnels about 50 feet long, connected by a crosscut, which exposes practically the entire width of the dike. At this point the dike shows 6 feet of well kaolinized pegmatite adjoining the west wall, 9 feet of semikaolinized material, and 20 feet of well kaolinized pegmatite adjoining the east wall. The country rock is completely kaolinized and forms a yellow claylike material. About one-third mile to the north and on

the general strike of this dike a somewhat narrower but otherwise similar dike is exposed. At various intermediate points similar dike material is exposed by test holes, indicating that the dike extends the entire distance, although its width and uniformity have not been proven. A smaller dike is exposed by a pit south of the road and one-eighth mile west.

"The two kaolinized bands exposed in the tunnel were sampled. When washed they yielded 44 per cent of kaolin, which showed the following chemical composition on analysis:

Composition of kaolin.

H_2O	13.10
SiO_2	45.95
Al_2O_3	39.20
Fe_2O_3	.05
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
BaO	.03
Na_2O	Trace.
K_2O	.50
	98.83

"This kaolin has a refractory value above 1,730° C. and the color is grade 2. The shrinkage dried at 110° C. is 4.4 per cent; when fired at 1,350° C., 12.9 per cent. The tensile strength of this kaolin dried at 110° C. is 29.5 pounds per square inch.

Properties in standard porcelain mixture.

This kaolin in the standard porcelain mixture fired at 1,350° C. has a translucency of 0.7 and the transmitted light is cream colored. Absorption is 4.6 per cent, the color grade 2. The shrinkage when dried at 110° C. was 3.4 per cent and fired at 1,350° C. 14 per cent. Tested under the fritted and raw-lead glazes the mass has a very pale green tint that is equally apparent under either glaze.

DILLSBORO. ALLISON PROSPECT.

"This prospect is north of Barkers Creek, 3 miles west of Dillsboro, Jackson County, N. C., on a branch one-half mile from the creek. A dike is exposed at three points. These exposures have a general west direction over a knoll and the exposed dike appears to be extremely lenticular. The exposures indicate the presence of kaolinized pegmatite, but the work done does not expose the pure dike material; hence no samples were taken.

"At a point 200 yards north on the opposite side of the branch a short tunnel has penetrated a lens of pegmatite which is, where exposed, about 5 feet in diameter and semicircular in shape, the dike material being entirely covered by an arch of mica gneiss. The material thus appears to form distinctly a lens or pocket, and its extent can be proven only by further mining.

"At a point one-eighth mile west of Barkers Creek Station a small kaolinized pegmatite dike is exposed in an abandoned mica shaft, but the workings have caved and the dike material cannot now be reached.

DILLSBORO. ROBERT ASHE PROSPECT.

"This prospect is 6 miles from Dillsboro, Jackson County, N. C., and one-half mile south of the main road between Webster and Cullowhee on the south side of Tuckasegee River. The kaolin was opened by a pit in a gap of the mountains, but the pit has completely fallen in and no kaolin is visible. The reported width is 14 feet. A small amount of kaolin is found in the dump, but much of this is only semikaolinized and considerable stained material is noted in connection with the kaolinized pegmatite. Mining for mica has been successful at various points in the neighborhood for a distance of one-fourth mile from this pit, and a more or less regular band of quartz extends in a general north-south direction from this deposit through the mica operations. Considerable further work is necessary to properly expose the kaolin at the old pit.

DILLSBORO. CAGLE GAP MICA MINE.

"This mine is 2 miles south of Dillsboro, Jackson County, N. C., and due south of the Dillsboro bridge across Tuckasegee River. The dike is opened in Cagle Gap by a pit at the roadside, where it strikes N. 20° E. and is 15 feet wide. The material along the walls is very rich in kaolin and is well kaolinized, but the middle of the dike for a width of about 8 feet is a very low-grade material and is unevenly kaolinized. The entire deposit is rather sandy. The part rich in kaolin was sampled. Washed by the standard laboratory process, it yielded 21 per cent of kaolin. The refractory value of this kaolin is 1,730° C. and the color grade 4. Its shrinkage when dried at 110° C. is 5.8 per cent and fired at 1,350° C. 13.3 per cent. The tensile strength is 16 pounds per square inch.

Properties in the standard porcelain mixture.

In this mixture and fired at 1,350° C. the kaolin gives a translucency of 0.65 and the transmitted light is cream colored. Absorption is 5.4 per cent. The

color is grade 4. The shrinkage when dried at 110° C. is 2.8 per cent and fired at 1,350° C. 12.6 per cent. Tested under the raw-lead and fritted glazes the color remains unaltered.

DILLSBORO. HARRIS CLAY COMPANY MINE.

"This mine is 5 miles southeast of Dillsboro, on the Murphy branch of the Southern Railway, Jackson County, N. C., which is the nearest shipping point.

"The pegmatite dike is very large, 200 to 300 feet wide and about 800 feet along. It forms a ridge that trends nearly north. In the center of the ridge is a 30-foot band of sugar quartz, adjoining which on the west is a 30-foot band of gneiss. The kaolinized pegmatite next the quartz is very rich in kaolin and averages 25 to 40 feet wide; adjoining it on the east is a wide band of kaolinized pegmatite that has a high quartz content. On the west side of the gneiss band is another wide band of kaolinized pegmatite. As in all pegmatite dikes in this district, numerous lenses of quartz and ferruginous sand are scattered through the deposit, but most of these lenses are well defined and may be removed by hand labor without injury to the adjacent material.

"Several smaller dikes (59 and 58) averaging 10 to 15 feet wide have been opened on ridges to the west and north of the main dike. All have been opened about 100 feet above Little Savannah Creek.

"The country rock of the district is Carolina gneiss which in this section is weathered to a maximum depth of 100 feet, the pegmatite being altered to about the same depth.

"The overburden is principally weathered gneiss which has a golden-red color due to iron. Where the dike material is in place at the present surface of the country, this iron stain has filtered into it and rendered it practically valueless for a depth of 4 to 12 feet.

"The overburden and the refuse dike material are removed by plow and scraper, which are supplemented by pick and shovel for the last foot above the valuable material. The removal of overburden proceeds usually 6 to 10 feet ahead of mining except where a quartz lens is encountered, when mining is continued up to the face of the quartz. The overburden walls are generally sloped about 70 degrees from the horizontal.

"Surface water causes little annoyance because the hillsides are steep and the dike is opened almost in the crest of the ridge.

"The method of mining is as follows: An open-cut, about 20 feet deep in the dike, is run along the face of the hill. The material is removed by pick and shovel and loaded into low cars which carry about 1,000 pounds each. They are pushed by hand or drawn by horse along

a tramway to the edge of the hill where the material is dumped into a chute and water pumped in, which conveys the crude kaolin to the washing plant in the valley below.

"For mining the lower portions of the deposit circular shafts are used. As the dike material at this point is kaolinized to a depth of about 100 feet, heavy timbering is necessary. The key-block system is used. The material is loosened by pick and shovel, explosives being used only for breaking masses of quartz. The shafts are sunk in benches of about 4 feet. The standard type of hoisting bucket and a drum hoist operated by a horse are used.

"At a depth of about 60 feet mining is somewhat hindered by water, which filters into the shaft. This is removed by the buckets in the same manner as the other material. When the bottom of the kaolinized material is reached, the robbing of the dike adjacent begins and proceeds by benches from the bottom to the top of the shaft, the timbering of each bench being removed and the bench being filled with waste from the surface before the level above is disturbed. This robbing and filling is worked in benches of about 4 feet, like shaft sinking.

"The crude kaolin is carried by flume to the washing plant, where it passes through two clay washers in succession and then into a long narrow tank in which are two sand wheels. The coarse material removed by the sand wheels passes through a third clay washer and into another long vat in which are two sand wheels. The coarse material removed by these wheels is considered as waste. The kaolin obtained by this second washing is conducted by a trough to the mica troughs, where it mixes with the kaolin from the first battery of washers. The mica troughs are in two batteries, thus dividing the flow of slip. Stationary screens are used above the concentrating tanks. The water removed from these tanks is pumped to the head of the flume line and re-used. The concentrated slip is pumped into filter presses. The clay cakes are dried principally in open-air sheds, although a steam drier is provided for 'rush' orders.

"The dry kaolin is hauled to Dillsboro over a tramroad in cars drawn by horses.

"Crude kaolin samples taken from this deposit and washed by the standard laboratory process yielded 49 per cent of kaolin. This kaolin was analyzed. It has the following chemical composition:

Composition of kaolin.

H_2O	13.99
SiO_2	46.95
Al_2O_3	37.73

Fe_2O_3	.15
TiO_2	.05
CaO	Trace.
MgO	Trace.
Na_2O	.18
K_2O	.60
	99.65

"This kaolin has a refractory value above 1,730° C. Its color is grade 1. Its shrinkage when dried at 110° is 6.1 per cent; when fired at 1,350°, 12.7 per cent. Its tensile strength is 24 pounds per square inch.

Properties in standard porcelain mixture.

This kaolin when introduced into the mixture and fired at 1,350° C. has a translucency of 0.69 and the transmitted light is cream colored. Absorption is 5.8 per cent. The color of the mass when fired at 1,350° C. is grade 1. The shrinkage at 110° is 3 per cent and when fired at 1,350° C. is 12.6 per cent. When tested under the raw-lead and fritted glazes this mass shows a pale-green tint, equally apparent under each glaze.

FRANKLIN. BRYSON PROSPECT.

"This property adjoins the West prospect on the west and is 8 miles north of Franklin, Macon County, N. C. The dike exposed has the same strike as that on the West prospect, but is opened at a level 50 feet lower by a tunnel 120 feet long. A width of nearly 15 feet of kaolin is exposed.

"This dike was carefully sampled. Washed by the standard laboratory process the material yielded 38 per cent of kaolin. This kaolin has a refractory value above 1,730° C. and its color is grade 2. Dried at 110° C. its shrinkage is 6.6 per cent and when fired at 1,350° C., 17.3 per cent. The tensile strength is 28 pounds per square inch.

Properties in the standard porcelain mixture.

In the mixture fired at 1,350° C. this kaolin gives a translucency of 0.68 and the transmitted light is cream colored. Absorption is 4.5 per cent. The color is grade 2. The shrinkage when dried at 110° is 3.4 per cent and when fired at 1,350° C., 14 per cent. When tested under the raw-lead and fritted glazes this kaolin shows a very pale-green tint, equally apparent under each glaze.

FRANKLIN. CHALK MICA MINE.

This mine is 2 miles north of the Franklin-Burningtown road and 6 miles northwest of Franklin, Macon County, N. C. The dike is from 15 to 20 feet in width. It strikes N. 30° E.; its dip is nearly vertical.

The material varies from a very pure kaolin, exposed in a tunnel, to a very sandy kaolin, exposed in an open-cut 20 yards distant. It has only been proven for a distance of about 50 yards, but there is no reason to doubt that it extends a considerable distance farther south.

"This material was sampled to give an average of the deposit so far as exposed and was washed by the standard laboratory process. The sample yielded 35 per cent of kaolin that has a refractory value above 1,730° C. The color is grade 3, but as the sample represented the entire deposit the elimination of a small portion of the poorer material would much improve the color. The shrinkage of this kaolin dried at 110° C. is 5.7 per cent and fired at 1,350° C. is 13.7 per cent. Its tensile strength when dried at 110° C. is 15.5 pounds per square inch.

Properties in standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. this kaolin gives a translucency of 0.65 and the transmitted light is cream colored. Absorption is 6 per cent, and the color is grade 3. The shrinkage is 3 per cent when dried at 110° C., and when fired at 1,350° C. is 14.8 per cent. Tested under the raw-lead and fritted glazes this mass assumes a pale-green tint, equally apparent under either glaze.

FRANKLIN. FRANK PROSPECT.

"This prospect is 2½ miles northeast of Franklin, Macon County, N. C., on the Franklin-Dillsboro road. The dike of kaolinized pegmatite follows a ridge and strikes about west, varying from 12 to 15 feet wide. This dike contains little fine quartz and is covered by only about 8 feet of overburden. It has been opened by a number of shafts and a tunnel, and from the tunnel which offers the best opportunity for sampling an average sample was taken.

"This sample when washed by the standard laboratory process yielded 31 per cent of kaolin. The refractory value of the kaolin is above 1,730° C., and the color grade 3. When dried at 110° C. it shrinks 5.4 per cent and when fired at 1,350° C. 15.1 per cent. The tensile strength of this kaolin is 18 pounds per square inch.

Properties in the standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. this kaolin gives a translucency of 0.63 and the transmitted light is cream colored. Absorption is 4.9 per cent. The color is grade 3. The shrinkage when dried at 110° C. is 3 per cent and when fired at 1,350° C. is 13.2 per cent. Tested under the raw-lead and fritted glazes this kaolin shows a pale-green tint, equally apparent under either glaze.

FRANKLIN. FRANKLIN KAOLIN TO MICA COMPANY MINES.

"These mines are 4½ miles north of Franklin, Macon County, N. C., at Iotla Bridge on the west bank of Little Tennessee River. Franklin is the nearest railroad station. The mines were originally worked for mica, but have more recently been worked for kaolin, being the first for kaolin west of the Cowee Mountains. The development consists of 10 tunnels and about 12 shafts. Some of the shafts have reached a depth of 120 feet. It contains a number of well-defined bands of sugar quartz, and these occur not only along the walls but also midway between the walls. The dike has been worked for 550 feet and varies in width from 10 to 100 feet, approximately. The pegmatite was remarkably low in quartz, yielding a very high-grade kaolin. The deposit is not completely worked out, but has been abandoned. Only one shaft is in such condition that the dike material can be studied, but the product of this mine had gained a reputation for high quality and fine color, and this shaft exposed kaolin which evidently represented a fair average of that in the dike.

"This material was sampled and washed by the standard laboratory process and found to contain 42 per cent of kaolin, which has a refractory value above 1,730° C. Its color is grade 1, and its shrinkage when dried at 110° C. is 5.2 per cent and when fired at 1,350° C. is 12.4 per cent. The tensile strength is 24 pounds per square inch.

Properties in the standard porcelain mixture.

In the mixture and fired at 1,350° C. this kaolin gives a translucency of 0.72 and the transmitted light is cream-white. Absorption is 6.2 per cent and color is grade 1. Dried at 110° C. the shrinkage is 3.2 per cent and fired at 1,350° C. the shrinkage is 12.8 per cent. The test under the raw-lead and fritted glazes shows that the color remains unaltered.

FRANKLIN. GURNEY CLAY COMPANY MINE.

"This mine is on the south side of Iotla Creek, 2 miles from the Little Tennessee River and 4 miles north of Franklin, Macon County, N. C.

"The kaolinized dike forms an expanded lens, averaging about 200 feet in width and 300 feet in length already proven, located on the north slope of a low ridge. Similar material is exposed in an abandoned mica shaft (28) one-eighth mile northwest. The Gurney mine was opened first by shaft at the lowest point on the north edge of the lens, where the overburden was not more than 2 or 3 feet. Shafts were sunk higher up the hill which show that the overburden does not increase much. However, the cost of shaft mining became so great that

open-cut mining was finally adopted. The open-cut has been advanced a depth of 20 to 30 feet into the lens and up to the present little quartz has been encountered. The lens consists of bands varying in kaolin content, some parts being very rich and others very low in kaolin. By mining the entire width of the dike, as nearly as possible, the operator is able to average this material and thus produce a product reasonably uniform in physical properties. Some of the shafts reach a depth of 100 feet, but below this level the degree of kaolinization hardly justifies mining.

"The material from the shafts has been hoisted by horse whims. The water, which flows into the shaft rapidly below about 60 feet, has up to the present been removed in buckets, which differ in size only from those for hoisting the dike material. Handling the water in this manner is difficult, and attention is being given to the installation of pumps, but all pumps tested have proven unsatisfactory because the grit in the water rapidly cuts out and ruins the valves.

"A tunnel from about the level of the creek bed, which is 100 feet below the open-cut level, is considered, and in this way the mine may possibly be drained effectively.

"The material removed from the deposit, whether by open-cut or by shaft, is conveyed to a central point by tramcars and there is mixed in constant proportion and emptied into a flume, the water for which is pumped a distance of 500 yards. This flume conveys the dike material to the washing plant, which consists of two washers and a long trough in which are two sand wheels. From the sand wheels the material passes to a long sand trough and from the sand trough to mica troughs. The mica troughs of this plant are constructed with absolutely no drop from entrance to exit, and the removal of the very fine sand and mica is therefore thorough.

"From the end of the sand troughs the kaolin slip passes through a battery of stationary screens and then into settling tanks. In the settling process aluminum sulphate is used as an aid in concentration. It is placed in bags and suspended in the trough between the screens and the settling tanks, and is found as effective as the alum employed at other plants through this district. After the excess water is removed, the kaolin slip is conveyed to a reservoir and thence pumped into the filter presses.

"After leaving the filter presses the kaolin is dried by two systems. One is the standard steam-drier system, in which the steam pipes are placed directly on the floor, and on these pipes the damp kaolin is heaped. These pipes are open at one end so that the steam is under no

pressure. The other system of drying is the open-air rack system. A building two stories high has in the upper story racks upon which the kaolin is spread; when dry this kaolin is dumped through the floor into the lower story, which is used for storage. This building has a ridge roof with an opening the full length along the ridge, covered with an additional narrow ridge roof, so that the escaping moisture from the drying kaolin passes off unretarded and does not condense on the underside of the roof as has been the case in some other drying sheds. The steam drier connected with this plant is 150 feet long by 24 feet wide. The open-air drier is 110 feet long by 24 feet wide and four racks high, each rack being 1½ feet deep.

"The dike material was carefully sampled and yielded 42.5 per cent of kaolin. However, at the time of this sampling the richer part of the dike only was exposed and the kaolin yield of the entire dike will probably not exceed 30 per cent.

"This kaolin was analyzed and found to have the following chemical composition:

Composition of kaolin.

H_2O	14.72
SiO_2	44.00
Al_2O_3	40.79
Fe_2O_3	.11
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
Na_2O	.07
K_2O	.55
	100.24

"This kaolin has a refractory value above 1,730° C., and its color is grade 1. Dried at 110° C. it shrinks 5.4 per cent and fired at 1,350° C. it shrinks 11.9 per cent. The tensile strength is 27.5 pounds per square inch.

Properties in standard porcelain mixture.

In the mixture fired at 1,350° C. the kaolin has a translucency of 0.72 and the transmitted light is cream-white. Absorption is 6.5 per cent. The color is grade 1. The shrinkage when dried at 110° C. is 3.2 per cent and when fired at 1,350° C. 12.4 per cent. Tested under the raw-lead and fritted glazes the color is not affected.

FRANKLIN. KASSON MICA MINE.

"This mine is 2 miles northeast of Franklin, Macon County, N. C., on the east side of the Franklin-Dillsboro road. The dike and its numerous stringers varying in width from 6 to 16 feet strike N. 40°

E. and dip from 75° W. to 80° E. The mine has been worked only for mica, but the dike where exposed is completely kaolinized and enormous quantities of high-grade kaolin have been ruined by mixture with wall rock in the dumps. The kaolinized dike is remarkably free from impurities except for small pockets of garnet-colored sand and altered biotite which is badly iron-stained. The presence of this iron stain would demand some care in mining, but its coloring power in the burned product is very much less than would be expected from the appearance of the washed clay in which this iron stain is allowed to remain. The portion of the dike that is most completely kaolinized and contains the least proportion of the iron stain was sampled. The sample when washed by the standard laboratory process yielded 41 per cent kaolin which had a pronounced pink color from this stain. The kaolin, however, has a refractory value above 1,730° C. and its color is grade 3. Its shrinkage is 4.7 per cent when dried at 110° and 14.1 per cent when fired at 1,350° C. The tensile strength of this kaolin dried at 110° is 18 pounds per square inch. If the garnet-colored sand and altered biotite were carefully removed the kaolin produced would doubtless be improved in color at least one grade, but owing to the fact that this deposit is worked entirely by tunnels on the 'ground-hog' system the present exposures are not extensive enough to justify a positive statement as to the possibility of working this dike for higher-grade kaolin.

Properties in standard porcelain mixture.

This kaolin in the mixture fired at 1,350° C. produces a translucency of 0.71 and the transmitted light is cream colored. Absorption is 5.6 per cent. The color is grade 3. Dried at 110° C. this mass shrinks 3.2 per cent and when fired at 1,350° C. the shrinkage is 13.3 per cent. When tested under the raw-lead and fritted glazes the tint of this mass is a very pale green, equally apparent under either glaze.

FRANKLIN. LENOIR PROSPECT.

"This prospect is 4½ miles west of Franklin, Macon County, N. C., on the Franklin-Andrews road. There is a dike averaging about 20 feet wide and exposed on the slope of a hill by two tunnels, one 20 feet below the other. The strike is west, the dip perpendicular. The kaolin exposed in the upper tunnel is free from bands or streaks of other material and has a small content of quartz. The material in the lower tunnel is more or less stained by small streaks of iron-stained sands at frequent intervals in the walls. The dike appears to be incompletely kaolinized in places, streaks of hard material almost approaching feldspar in appearance being encountered at frequent intervals,

but most of these streaks are narrow. The lower tunnel contains a number of lenses or pockets of micaceous material embedded in stained kaolin, but they are small and doubtless could be easily removed.

"The kaolin from this deposit was sampled. It yielded by washing 38 per cent of kaolin. The shrinkage of this kaolin at 110° C. is 6.4 per cent and at 1,350° C. is 14.9 per cent. The tensile strength at 110° C. is 20 pounds per square inch. The color is grade 1 and the refractory value is above 1,730° C.

Properties in standard porcelain mixture.

In this mixture the shrinkage at 110° is 3.6 per cent; fired 1,350° C., 11.6 per cent. The translucency is 0.67 and the transmitted light is cream colored. The absorption is 7.1 per cent. The color is grade 1. Under the fritted and raw-lead glazes the color of the porcelain mixture is not altered.

FRANKLIN. LYLE PROSPECT.

"This prospect is 1½ miles northeast of Franklin, Macon County, N. C., on the Dillsboro road. It is a dike about 15 feet wide that strikes northeast and dips 75° NW. There is little fine mica or other impurity in the dike material, but the degree of kaolinization is variable. Proper sampling was impossible because the dike has been opened to a depth of only about 10 feet, and surface drainage may have removed much of the fine kaolin from this part of the dike.

"The least exposed part of the deposit was carefully sampled. The sample contains 26 per cent of kaolin when washed by the standard laboratory process. This kaolin has a refractory value of 1,690° C. and its color is grade 3. Its shrinkage when dried at 110° C. is 5.2 per cent and when fired at 1,350° C. is 15.8 per cent. The tensile strength of the kaolin dried at 110° is 16 pounds per square inch.

Properties in standard porcelain mixture.

This kaolin introduced into the mixture and fired at 1,350° C. gives a translucency of 0.67 and the transmitted light is cream colored. Absorption is 3.1 per cent. The color is grade 3. Dried at 110° the shrinkage is 3.3 per cent and when fired at 1,350° C. the shrinkage is 12.8 per cent. Tested under the raw-lead and fritted glazes there is no change in color.

FRANKLIN. M'GUIRE PROSPECT.

"This prospect is 4 miles northwest of Franklin, Macon County, N. C., on a west spur of Tremont Mountain, one-eighth mile south of the McGuire feldspar mine and on about the same elevation. The dike strikes northeast and dips 80° S., it is kaolinized and about 18 feet thick at this point. It is free from associated minerals, but contains a small

amount of semikaolinized material. There are two tunnels into the dike, but no material has been sold.

"The material exposed was sampled and washed. It showed a kaolin content of 42 per cent. This kaolin has the following chemical analysis:

Analysis of kaolin.

H_2O	14.00
SiO_2	46.35
Al_2O_3	39.00
Fe_2O_3	.30
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
Na_2O	.00
K_2O	.50
	100.15

"The shrinkage of this kaolin at 110° C. is 5.7 per cent, the tensile strength per square inch 27.5 pounds, the shrinkage when fired at 1,350° C., 10.5 per cent. The color is grade 3 and the refractory value is above 1,730° C.

Properties in standard porcelain mixture.

The shrinkage of this kaolin in the mixture at 110° is 3.2 per cent. When fired at 1,350° C. it has a shrinkage of 14.2 per cent and a translucency of 0.72; the transmitted light is cream colored. Absorption is 5.4 per cent. The color is grade 3. Under the fritted and raw-lead glazes the color remains unaltered.

FRANKLIN. PORTER MICA MINE.

"About 2 miles west of Franklin, Macon County, N. C., is the old Porter mica mine. It has long been abandoned and the shafts have caved, preventing any proper sampling of the deposit. The dumps about the shafts show considerable kaolin of fair quality, but no record of the dimensions of the dike is obtainable.

FRANKLIN. MOORE MICA MINE.

"This mine is 1½ miles north of Franklin, Macon County, N. C., on the west bank of the Little Tennessee River, about 80 feet above the river. The mine is reported to have been opened by tunnels several years ago, but is now opened only by two shafts which do not cut the main dike. The section exposed by the shaft is 9 feet wide and shows kaolin very free from impurities and low in quartz. A considerable part of this dike, however, is not completely kaolinized. Where exposed it is covered with about 20 feet of overburden, strikes N. 40° E., and dips 85° N.

"The kaolin material was sampled and by the laboratory washing process found to contain 34 per cent of kaolin. The refractory value of this kaolin is above 1,730° C. Its color when fired at 1,350° C. is grade 1; its shrinkage when dried at 110° C. is 7 per cent and when fired at 1,350° C. is 15.7 per cent. The tensile strength of this kaolin dried at 110° C. is 26 pounds per square inch.

Properties in standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. this kaolin shows a translucency of 0.64. The transmitted light is cream white. Absorption is 7.6 per cent. The color is grade 1. The shrinkage when dried at 110° is 3 per cent and when fired at 1,350° C. 12 per cent. Tested under the fritted and raw-lead glazes this porcelain mixture assumes a pale-green tint.

FRANKLIN. MYERS PROSPECT.

"This prospect is due southwest from the Sloan prospect, about 4 miles below Franklin, Macon County, N. C. It is, however, on the south side of the Little Tennessee River and directly on the line of the strike of the dike on the Sloan prospect. The dike on the Myers prospect follows a low ridge and is exposed by small pits. It is opened at one point for a distance of 25 feet along the strike and shows a maximum width of 12 feet. The depth of the opening is only about 5 feet, which is not enough to properly remove the surface material; hence the actual quality of the dike could not be accurately determined. Indications of this dike continuing in both directions are evident from surface marks, but no work has been done to prove its continuation. As this property is on the south side of the Little Tennessee River its distance by road from the shipping point, which is Franklin, N. C., is about 3½ miles.

FRANKLIN. RABY MICA MINE.

"This mine is north of Tremont Mountain and on the west side of Halls Mill Creek, 1 mile west of Burningtown road and 4 miles from Franklin, Macon County, N. C.

"The dike with a number of stringers has a total width of almost 100 yards, and strikes N. 10° E. across a ridge which runs almost due west and has a width of about one-fourth mile. The stringers average about 15 feet wide, and have been proven for about 200 feet on each side of the ridge and about 100 feet below the crest of the ridge. The kaolin penetrated by tunnels at low levels shows a higher sand content, undoubtedly because it is material accumulated by a slide or slip from the main body. Dikes of similar structure are exposed by pros-

pect tunnels one-fourth mile north and one-fourth mile east. A dike of lower grade is exposed on a north slope one-fourth mile southeast of the Raby mine.

"The kaolin material was carefully sampled and by the laboratory washing process yielded 45 per cent of kaolin. By analysis it showed a chemical composition as follows:

Composition of kaolin.

H_2O	13.80
SiO_2	46.90
Al_2O_3	38.60
Fe_2O_3	.25
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
Na_2O	.26
K_2O	.39
	100.20

"This kaolin had a refractory value above 1,730° C. Its color when fired to 1,350° C. is grade 3. Its shrinkage when dried at 110° is 6.25 per cent, and when fired to 1,350° C. is 13.5 per cent. Dried at 110° this kaolin has a tensile strength of 21.5 pounds per square inch.

Properties in standard porcelain mixture.

In the mixture when fired at 1,350° C. this kaolin gives a translucency of 0.71 and the transmitted light is cream colored. Absorption is 6 per cent. The color is grade 3. The shrinkage at 110° is 2.2 per cent, when fired at 1,350° C. 13.2 per cent. When the fritted or the raw-lead glaze is applied to the porcelain mixture the color of the body through the glaze appears to be a pale green and is as pronounced under one glaze as under the other.

FRANKLIN. ROCHESTER MICA MINE.

"The location is the same as the Lyle Knob mica mine, 5 miles north of Franklin, Macon County, N. C., but there is a kaolinized dike 150 feet to the east and 25 feet above the exposure of the fresh pegmatite dike. This kaolin seems to be remarkably pure and of very fine quality, but the dike contains many small iron garnets, which would make the mining of the kaolin somewhat difficult. The dike strikes N. 10° E. and dips 80° W., like the fresh pegmatite dike, is 5 to 10 feet in width, and seems to be very uniform from wall to wall. It has been exposed by tunnel along the strike for about 40 feet. This tunnel is 50 to 60 feet below the crest of the mountain.

"The material was carefully sampled and washed and showed a kaolin content of 44 per cent. The kaolin was tested and found to have a refractory value above 1,730° C. The color is grade 2. The shrinkage when dried at 110° C. is 6.2 per cent and when fired at 1,350° C. is 13.8 per cent. The tensile strength of this kaolin dried at 110° C. is 24 pounds per square inch.

Properties in standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. this kaolin gives a translucency of 0.70 and the transmitted light is cream colored. Absorption is 5.8 per cent. Its color is grade 2. Dried at 110° C. its shrinkage is 2.6 per cent, and fired at 1,350° C. is 13 per cent. Tested under the raw-lead and fritted glazes the tint of this mass is very pale green, equally apparent under either glaze.

FRANKLIN. SANDERS PROSPECT.

"This prospect is south of Lyle Knob and 5 miles north of Franklin, Macon County, N. C., on the road between Iotla Bridge on the Little Tennessee River and the Franklin-Dillsboro road. The kaolinized portion of the dike, about 20 feet wide, strikes N. 20° W. and follows the crest of a low ridge. It is remarkable in that it is clearly defined by quartz bands along its walls. In addition to the 20 feet of kaolin contained in this dike there is also a width of from 8 to 15 feet of low-grade pegmatite material. The dike is opened by a tunnel 120 feet long and was sampled at the face of this tunnel where its full width is exposed. The sample when washed yielded 29 per cent kaolin.

"The refractory value of this kaolin is above 1,730° C. and the color is grade 3. The shrinkage when dried at 110° C. is 4.5 per cent, and when fired at 1,350° C. is 13.8 per cent. The kaolin has a tensile strength of 14 pounds per square inch.

Properties in the standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. the kaolin gives a translucency of 0.69 and the transmitted light is cream colored. Absorption is 5.3 per cent. The color is grade 3. Dried at 110° C. the shrinkage is 3.4 per cent, and fired at 1,350° C. the shrinkage is 13.5 per cent. Tested under the fritted and raw-lead glazes it shows a pale-green tint, equally apparent under each glaze.

FRANKLIN. SLOAN PROSPECT.

"This prospect is on the north side of the Little Tennessee River, 4 miles below Franklin, Macon County, N. C. The dike is from 8 to 10 feet wide, strikes northeast, and dips 80° NW. It is exposed by only a single open-cut 50 feet above the Little Tennessee River, and

a proper study was therefore impossible. The cut is the width of the dike and about 8 feet into the face of the hill. The dike is completely kaolinized, but contains a considerable quantity of fine quartz and a narrow quartz band on the northwest side along the hanging wall. There is much stained mica along the foot wall which would demand careful mining if to be eliminated.

"The prospect was sampled. The sample washed by the standard laboratory process was found to contain about 30 per cent pure kaolin. The kaolin was tested and has a refractory value above 1,730° C. and the color is grade 3. The shrinkage when dried at 110° C. is 6.4 per cent, and when fired at 1,350° C. is 15.2 per cent. The tensile strength of the kaolin dried at 110° C. is 22 pounds per square inch.

Properties in standard porcelain mixture.

This kaolin introduced into the mixture and fired at 1,350° C. gives a translucency of 0.69 and the transmitted light is cream colored. Absorption is 7.1 per cent. The color is grade 3. Dried at 110° C. the shrinkage is 3.2 per cent, and fired at 1,350 ° C. is 12.3 per cent. Tested under the raw-lead and fritted glazes the tint of this mass is pale green, equally apparent under each glaze.

FRANKLIN. SMITH PROSPECT.

"This prospect is on Little Tellico Creek, 1½ miles southwest of Tellico Creek and 12 miles northwest of Franklin, Macon County, N. C.

"The dike, which is completely kaolinized, is exposed by a 40-foot tunnel and by an open pit on a hillside 75 feet above Little Tellico Creek. The dike is nearly 200 feet wide, but several broad horses of wall rock reduce the actual width of pegmatite material to about 50 feet. The dike has a general northeast strike and dips 80° W. where exposed. The pegmatite is reasonably free from foreign matter, the associated minerals being muscovite and quartz.

"This material was sampled. On washing it yielded 39 per cent kaolin. This kaolin has the following chemical analysis:

Composition of kaolin.

H_2O	12.55
SiO_2	48.05
Al_2O_3	37.69
Fe_2O_3	.31
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
Na_2O	.02
K_2O	.91
	99.53

"The shrinkage of this kaolin in drying at 110° C. is 6.8 per cent, and when fired at 1,350° C. is 12 per cent. Its tensile strength dried at 110° C. is 20.5 pounds per square inch. Its color is grade 4, and the refractory value is 1,670° C.

Properties in standard porcelain mixture.

In this mixture the kaolin showed a shrinkage dried at 110° C. of 3.2 per cent, fired at 1.350° C. of 12.4 per cent. The translucency at 1,350° C. is 0.71 and the transmitted light is cream colored. Absorption at 1.350° C. is 4 per cent. Color at 1,350° C. is grade 4. Tested under the raw-lead and fritted glazes the color remains unaltered.

FRANKLIN. SOUTHERN CLAY COMPANY MINES.

These mines are on one of the foothills of Tremont Mountain, 1 mile northwest of Franklin, Macon County, N. C., and one-half mile north of the Franklin-Andrews road. They have been worked out since the preparation of this report began, but the deposit and the method of mining are of especial interest and are therefore described. The main workings showed a well-defined kaolinized pegmatite dike, 16 to 20 feet wide, that has a broad band of sugar quartz along the north wall and another quartz band about midway in the dike. The wall rock is gneiss and the contact between the dike and the gneiss is very sharp, the stain from the decomposed gneiss rarely penetrating the dike more than 1 inch. This dike strikes almost due east and dips 70° S.

"The kaolinized pegmatite contains as impurities small pockets of garnet sand and isolated patches of weathered biotite that are surrounded by a garnet-colored claylike material. This sand seems to have no tendency to stain adjacent material, but the weathering of the biotite invariably causes a stain for 3 or 4 inches in every direction. Very little sheet mica is found, but large quantities of first-class punch mica in plates from three-fourths inch to 2 inches wide have been removed and rejected with other refuse.

"The mining of this dike was very expensive because shafts alone were used, no material being removed by open-cut work.

"The overburden varies from 5 to 25 feet. The thick quartz bands in the hanging wall and in the middle of the dike also added much to the cost of mining, as their removal was absolutely imperative in sinking vertical shafts. These shafts were invariably sunk directly into the dike, and because of the dip they passed through it and into the foot wall, so that it was necessary to remove big masses of quartz, sink into the foot wall, and then run a crosscut from the bottom of a shaft in order to reach the kaolin.

"The deposit for a depth of 25 feet into the dike shows a high grade of kaolin of fair plasticity. At about this depth irregular lenses of semikaolinized feldspar in the form of very fine sand were encountered in some of the shafts. Below this level much very fine kaolin is found, and to a depth of about 80 feet the kaolin content of the dike is in excess of what would be expected from the kaolinization of average pegmatite, and approaches very closely the theoretical maximum from the decomposition of feldspar. Below the 80-foot level the dike material soon changes to semikaolinized feldspar with isolated patches of plastic kaolin, and below the 100-foot level plastic kaolin is rarely found, but the material is a rich kaolinized feldspar containing very little quartz and is remarkably high grade as regards color. At this 100-foot level well-defined and practically fresh crystals of orthoclase are found embedded in the slightly kaolinized material.

"This deposit is reasonably uniform for about 120 feet, but disappears almost completely on the east slope of the hill. Another dike which was supposed to promise considerable quantities of kaolin lies parallel to this dike and 30 yards south of it. This dike was explored by pits. The surface material proved to be stained, but as the high-grade material of the main dike was also stained near the surface the owners believed that the small dike would likewise improve in quality with depth. This, however, failed to be the case, and all the dike material was rejected as unmarketable.

"On an isolated knoll one-eighth mile northeast of the small dike just described another well-defined dike was exposed by a shaft, but it proved merely an expanded lens and yielded kaolin in commercial quantities for only about 50 feet. Its maximum width was about 15 feet. Numerous other small dikes are on this property, but they were found to be too narrow to be profitably worked by shafts.

"Mining was by circular shaft in the ordinary manner of this district, electric hoists being used to remove rock and kaolin from the lower levels.

"Below about 45 feet the inflow of water caused great annoyance to the miners, and at 60 feet the removal of the water became a considerable problem. At lower levels the flow continued to increase until at 100 feet at least 50 per cent of the total time of operation was spent in removing the water, which was hoisted in barrels with bands and braces like the half barrels generally used to remove the dike material. The flow of water at times became so great that an extra crew of men had to be employed to enable the kaolin miners to work. Removal of this water in any other way than by bailing was never attempted, and it is not

known whether this deposit could have been drained by tunneling, a method that has proved so successful in draining other deposits in this district.

"The dike material was conveyed to the washing plant by flumes, the water for which was pumped from the valley below with a 3-cylinder pump. The larger proportion of semikaolinized material found at the lower levels of these shafts necessitated putting in screens to remove the large lumps of hard material which constantly clogged the flume and caused it to overflow. At the washing plant the material passed through two batteries, consisting of one washer and one sand wheel each; the refuse from the first sand wheel went into the second washer, but the kaolin from the first sand wheel went directly to the second sand wheel and not through the second washer. The material from this washing process passed into a shallow sand-settling tank 6 by 6 by 1½ feet deep. The outlet of this settling tank is at an angle of 45 degrees with the intake, thus giving the sand a better opportunity to settle. From this settling tank the kaolin-bearing material was conveyed by troughs to a rotary screen, where the greater proportion of the fine mica was removed. The finest material passed through 12 mica-settling troughs, each 40 feet in length, making the total length 480 feet, before it reached the 140-mesh screen which this company uses. Numerous screens were tested by this company, and the revolving screen was found to be the most efficient and economical for its work.

"The kaolin passing through the screen ran into a trough that contained a battery of electromagnets for the removal of any iron that may have been taken up by contact with the machinery in the washing process. From these magnets the material passed over a bed of alum which aided the settling of the clay slip and simplified the removal of the excess water. The material then passed to the settling tanks where the excess water was removed. From the settling tanks the material was pumped into a cistern that was constantly agitated, and from this the slip was pumped to the filter presses, where most of the kaolin was removed. The pressed kaolin from the filter presses was loaded on rack cars, which were run into a tunnel drier heated by hot air obtained by forcing air through steam coils with fans. The floor of the drier has a slight grade, sufficient to cause the cars to move forward when the car next the outlet is removed. The kaolin from the drier was carried by an elevator and conveyor to stock bins adjoining the drier, and from these bins the material was loaded into wagons and hauled 1 mile to the railroad.

"The material produced by the principal dike worked on this property was sampled and was subsequently washed by the standard laboratory process. It yielded 40 per cent of kaolin. The material was selected with care and has been accepted as the standard of color value in the classification of kaolins in this district. Its refractory value is above 1,730° C., and its color is grade 1. Dried at 110° C., it shrinks 4 per cent, and fired at 1,350° C., it shrinks 11 per cent. The tensile strength is 25 pounds per square inch.

Properties in the standard porcelain mixture.

In the mixture and fired at 1,350° C. this kaolin has a translucency of 0.93 and the transmitted light is white. Absorption is 7 per cent. The color is grade 1. The shrinkage when dried at 1,350° C. is 3.4 per cent, and when fired at 1,350° C. is 9.9 per cent. Tested under the raw-lead and fritted glazes the color remains unaltered.

FRANKLIN. WEST PROSPECT.

"This prospect is one-half mile southeast of West Mills and 1 mile north of the Franklin-West Mills road, 8 miles north of Franklin, Macon County, N. C., on the Little Tennessee River.

"The dike is approximately 25 feet wide, strikes west, and dips 80° S. Two tunnels run 40 feet into the hill, one 25 feet below the crest of the hill and the other 20 feet below the first. A large part of this dike is not completely kaolinized and carries considerable quartz. Numerous small streaks of stained material similar to the decomposed country rock run through the deposit at various angles. The tunnels in the West prospect are on the east slope of the ridge. On the opposite slope in the Bryson prospect a tunnel 120 feet long and 75 feet below the crest of the hill cuts material which is undoubtedly a part of the same dike, but which strikes northwest. Its dip is practically perpendicular. The kaolin exposed in this tunnel is remarkably clean and free from impurities.

"The kaolin exposed on the West prospect was carefully sampled and washed, yielding 29 per cent kaolin. This kaolin was analyzed and showed the following chemical composition:

Composition of kaolin.

H_2O	12.70
SiO_2	48.92
Al_2O_3	36.37
Fe_2O_3	.37
TiO_2	.02

CaO	Trace.
MgO	Trace.
Na_2O	.11
K_2O	.29
	98.78

"This kaolin has a refractory value of 1,730° C. Its color when fired to 1,350° C. is grade 3. Its shrinkage on drying 110° is 7 per cent, and the total shrinkage at 1,350° C., 18 per cent. When dried at 110° this kaolin has a tensile strength of 24 pounds per square inch.

Properties in standard porcelain mixture.

In the mixture fired at 1,350° C. this kaolin has a translucency of 0.66 and the transmitted light is cream colored. Absorption is 4.3 per cent. The color is grade 3. The shrinkage when dried at 110° is 3.6 per cent and fired at 1,350° C. is 14.2 per cent. When tested under the fritted and raw-lead glazes this kaolin shows a pale-green tint, equally apparent under either glaze.

LINCOLNTON. PIEDMONT TIN MINING COMPANY MINES.

"These mines are 2½ miles southeast of Lincolnton, Lincoln County, N. C. There are four distinct dikes of more or less kaolinized pegmatite. These dikes, which strike N. 20° E., contain numerous narrow bands of yellow sand and of gold-colored clay. One dike known as the 'Jake vein' is fairly free from stain and possibly contains some good commercial kaolin. These mines have been worked entirely by tunnels, and the dikes have been thoroughly prospected in the same way. The water encountered is diverted to a central point, collected in a pit, and pumped to the surface; in this way the entire dike is drained. The degree of kaolinization of these dikes seems to increase toward the southwest end, and even through the dikes carrying considerable stained material it is likely that kaolin production could be made profitable inasmuch as this kaolin is a by-product in mining cassiterite.

"Material from the 'Jake vein' was sampled and washed. It shows a kaolin content of 26 per cent. The washed product has a chemical composition as follows:

Composition of kaolin.

H_2O	12.00
SiO_2	48.50
Al_2O_3	37.35
Fe_2O_3	.85
TiO_2	Trace.
CaO	Trace.

MgO	Trace.
Na_2O	.32
K_2O	1.02
	100.04

"This kaolin has a refractory value of 1,710° C. Its color is grade 5. Its shrinkage is 4.4 per cent when dried at 110° C., and fired at 1,350° C. 8.1 per cent. The tensile strength when dried at 110° is 16.5 pounds per square inch.

Properties in standard porcelain mixture.

When introduced into the mixture fired at 1,350° C. this kaolin gives a translucency of 0.78 and the transmitted light is yellow. Absorption is 3.5 per cent. The color is grade 5. When dried at 110° this mass shrinks 2.2 per cent, at 1,350° C. 13 per cent. Tested under the fritted and raw-lead glazes the tint is unaltered.

MICAVILLE. THOMAS PROSPECT.

"This prospect is 1 mile north of Micaville, Yancey County, N. C., which is the nearest shipping point. The pegmatite dike is on a very narrow ridge and exposed in such manner that its width cannot be determined from present openings. It strikes N. 45° E. A tunnel 3 feet wide has been driven directly on the strike and a small shaft 40 feet deep has been sunk at the end of this tunnel. In both good kaolin is exposed. At a short distance to the northeast, on a ridge to which this dike is supposed to extend, the material is of good color but contains a proportion of sand. This high sand content is observed in the shallow pit which exposes the dike at the ridge. Various test holes have been dug on this property, but it is not possible to state accurately the width of any of the dikes exposed.

MICAVILLE. WILSON PROSPECT.

"This prospect is one-half mile southeast of Micaville, Yancey County, N. C. The dike follows the south and east face of a ridge and varies in width from 30 to 100 feet. It also appears on the west slope of the ridge in several tunnels. The pegmatite seems to be well kaolinized, but contains many narrow bands of yellow sand and clay, which, however, can doubtless be removed without serious injury to the dike material. This prospect has been proven for about 700 feet by numerous shafts and tunnels and appears to be of uniform quality wherever exposed.

"A tunnel midway between the limits of this dike was carefully sampled. The sample when washed yielded 28 per cent of kaolin. This

kaolin has a refractory value above 1,730° C. and its color is grade 2. Dried at 110° C. it shrinks 4.2 per cent and fired at 1,350° C. it shrinks 13.2 per cent. It has a tensile strength of 24 pounds per square inch.

Properties in standard porcelain mixture.

In the mixture and fired at 1,350° C. this kaolin gives a translucency of 0.72 and the transmitted light is cream colored. Absorption is 4.3 per cent. The color is grade 2. The shrinkage dried at 110° C. is 3.2 per cent and fired at 1,350° C. 13.6 per cent. Tested under the fritted and raw-lead glazes this kaolin shows a very pale-green tint, equally apparent under each glaze.

PENLAND. HARRIS CLAY COMPANY PENLAND MINE.

"This mine is on the north side of the North Toe River, on a high ridge having a general north trend, and is one-fourth mile east of Penland, Mitchell County, N. C.

"The deposit is in the form of an expanded lens 120 to 160 feet wide. It strikes N. 25° E. The pegmatite is very fine grained and has a texture not unlike granite, the kaolinization of a considerable part of the dike not being sufficient to destroy the texture of the original rock. The southeast wall is well defined, but the northwest wall is hardly distinguishable, as the dike material on that side grades gradually into a hard, granite-like rock producing little or no kaolin. The west part of the dike contains numerous irregular streaks of iron-stained material. The mine has been opened for about 400 feet along the strike and for a depth of about 50 feet, below which the kaolin yield is too small to justify mining. About 50 yards beyond the southeast wall of this deposit a dike approximately 10 feet in width and very rich in kaolin has been exposed, but has never been developed.

"The dike now being worked was sampled. Washed by the standard laboratory process the sample yielded 22 per cent of kaolin. This kaolin has a refractory value of 1,730° C. Fired at 1,350° C. its color is grade 4. Its shrinkage when dried at 110° C. is 3.4 per cent, and when fired at 1,350° C. is 11.6 per cent. The tensile strength of the kaolin dried at 110° C. is 12 pounds per square inch.

Properties in standard porcelain mixture.

This kaolin introduced in the mixture and fired at 1,350° C. has a translucency of 0.62. The transmitted light is cream colored. Absorption is 5 per cent and color is grade 4. Dried at 110° C. this mass shrinks 3.2 per cent, and when fired at 1,350° C. shrinks 13 per cent. Tested under the raw-lead and fritted glazes the color of this mixture becomes a pale green, equally apparent under each glaze.

RUTHERFORDTON. ISINGLASS HILL MICA MINE.

"This mine is 3 miles north of Rutherfordton in Rutherford County, N. C., on the Southern Railway. There is no railroad switch or station nearer than Rutherfordton. This dike varies from 6 to 50 feet wide and is proven for one-fourth mile along the crest of a low ridge. It strikes N. 20° E. and dips 80° W. The dike rock is pegmatite in various stages of kaolinization. The material adjoining the west wall is generally more thoroughly kaolinized than that in the eastern part, the dike being divided in the middle by a band of sugar quartz from 1 to 3 feet wide. The kaolinized pegmatite contains but little fine quartz, but this is smoky quartz in sharp elongated particles. In various parts of the weathered dike are nodules of asbolite, but little or none is found in the band of sugar quartz. This mine has been opened to a depth of only about 20 feet by both shafts and tunnels, the dike structure remaining very uniformly as above described.

"The kaolinized half of the dike was sampled and by the laboratory washing process yielded 42 per cent of kaolin which has a refractory value of 1,730° C. The color of this washed kaolin is grade 5. When dried at 110° it has a shrinkage of 2.8 per cent, and when fired at 1,350° C., 11.3 per cent. The tensile strength when dried at 110° is 8 pounds per square inch.

Properties in standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. this kaolin shows a translucency of 0.64 and the transmitted light is cream colored. Absorption is 8.8 per cent. The color of the mass when fired is grade 3, as compared with grade 5 for this kaolin burned alone. When dried at 110° the mass shrinks 2.2 per cent, and when fired at 1,350° C. it shrinks 12.4 per cent. Tested under the raw-lead and fritted glazes the color is unaltered.

SHELBY. TOM BAXTER MICA MINE.

"This mine is in Lincoln County, N. C., 12 miles northeast of Shelby and 3 miles southeast of Fallston on the Fallston-Lincolnton road. The nearest shipping point is Waco, 4 miles distant.

"The mine has not been worked for several years and the exposure conveys little information as to the extent of the dike. The area in which shafts have been sunk is about 40 feet long, although there are indications of a continuation of the dike in the adjoining fields for 100 feet or more in both directions. The width of the dike is reported to be almost 100 feet. The general direction of the strike is N. 50° to 70° E. Only at one point was it possible to observe the kaolin in place, but the

dumps from the mica workings carry considerable very fine kaolin, indicating that there must be some in the deposit. Workmen who were employed in mining mica state that at about 30 feet they found kaolin practically free from quartz and in one shaft reached a depth of 47 feet, but the dike material was so soft and caved so badly that the mine was abandoned. Water was struck at about 35 feet, and the difficulty of removing it with the crude facilities provided also discouraged the attempt to mine mica.

"The one point at which the dike is exposed was carefully sampled. Washed by the laboratory washing process the sample yielded 49 per cent of kaolin, which has a refractory value above 1,730° C. and a color of grade 2. This kaolin dried at 110° shrinks 4.4 per cent and fired at 1,350° C. it shrinks 12.2 per cent. Its tensile strength when dried at 110° C. is 8 pounds per square inch.

Properties in standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. this kaolin shows a translucency of 0.73 and the transmitted light is cream colored. Absorption is 8.1 per cent. The color of the mass is grade 2. The shrinkage is 1.6 per cent when dried at 110° C. and 10.8 per cent when fired at 1,350° C. Tested under the raw-lead and fritted glazes this mass is unaffected in tint.

SHELBY. GREEN MICA MINE.

"This mine is 7 miles northwest of Shelby, Cleveland County, N. C. It was worked for mica about 1870 and again worked in a small way a few years later. The openings were all shafts; these are now completely caved, making satisfactory sampling impossible. The dike, as nearly as could be determined, is about 12 feet thick with numerous stringers running nearly parallel. The strike is about N. 70° E. and the dip approximately 75° W. Bands of sugar quartz from 2 to 4 feet thick occur along the hanging wall. In places the dike material is almost completely kaolinized, and it is reported in the neighborhood that much excellent kaolin was exposed in the shafts. The present exposures, however, are so small and so badly stained from infiltration of surface water that an estimate of the quality or quantity of kaolin available is not attempted.

SPRUCE PINE. HARRIS CLAY COMPANY SPRUCE PINE MINE.

"This mine is 2½ miles north of Spruce Pine, Mitchell County, N. C., and on the east side of Beaver Creek.

"The vast lens or thick dike of kaolinized pegmatite has an irregular structure. Its general trend is northwest. Where worked the dike is

about 120 feet wide, but the northeast part for a width of 50 to 70 feet is much richer in kaolin than the southwest. An additional stringer has been located 25 feet east of the lens since the study of this deposit began, having a width of about 20 feet and a general direction north. The material in this small lens or stringer is similar in every way to that of the eastern part of the mine. The pegmatite of the dike is well kaolinized, but its quartz content is very high. The mine has been worked by open cut to a depth of about 20 feet and by shaft to an additional depth of 55 feet, below which the kaolinization of the pegmatite has not advanced far enough to make mining profitable. The dike material is removed from the shafts by steam hoists and piled in heaps at the level of the open-cut. From this point it is shoveled into a flume, the water for which comes from a small mountain stream above the mine, and is flushed one-fourth mile to the washing plant. This plant has two batteries, each consisting of a washer and sand wheel, and from them the material passes to a sand trough and thence to the mica-settling trough. From the latter the clay slip passes through 100-mesh screens into a flume which carries it 2½ miles to the railroad, where the settling and drying plant is located. Here the slip is passed over a second battery of screens to remove any material caught in transit and goes to the settling tanks through a trough in which are suspended bags containing alum to aid concentration. From the settling tanks the concentrated material is removed to agitators and pumped into filter presses, of which this plant has two.

"The kaolin from the filter presses goes to either the open-air or the steam drier. The latter is a long building having a floor covered with steam pipes on which the pressed kaolin is piled directly. The steam pipes are closed at one end, whereas in most of the steam drying plants throughout this district the pipes are open at one end and the steam is allowed to escape into the air.

"The open-air drier is unique in that it has a removable roof. The kaolin is piled on a simple system of racks, but the roof, which is of the ridge type, is constructed independently of the framework of the building, and rests on a track. When the weather is favorable it can be rolled off entirely, allowing the sun to shine directly on the drying material.

"The washing removes a large proportion of fine white mica, the yield of this material being estimated as 8 to 12 per cent of the kaolin produced. From 30 to 40 per cent of the mica separated is finer than 100 mesh and should be directly marketable as pulverized mica.

"The deposit was sampled as well as possible to obtain an average of the entire area exposed; it yielded 24 per cent of washed kaolin.

"This kaolin was analyzed and found to have the following chemical composition:

Composition of kaolin.

H_2O	14.80
SiO_2	45.20
Al_2O_3	38.45
Fe_2O_3	.45
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
Na_2O	.00
K_2O	.65
	99.55

"The refractory value of this kaolin is above 1,730° C. and the color grade 3. The shrinkage of the kaolin dried at 110° C. is 4 per cent and fired at 1,350° C. is 12.6 per cent. The tensile strength is 8 pounds per square inch.

Properties in standard porcelain mixture.

In the mixture fired at 1,350° C. the translucency is 0.67 and the transmitted light is cream colored. Absorption is 4.2 per cent. The color is grade 3; the shrinkage is 3.8 per cent when dried at 110° C. and 12.6 per cent fired at 1,350° C. Tested under the raw-lead and fritted glazes the kaolin showed a very pale green tint, equally apparent under both glazes.

SPRUCE PINE. OLLIS PROSPECT.

"This prospect is 6 miles northeast of Spruce Pine, Mitchell County, N. C., and 1 mile east of the Spruce Pine-Plumtree road. There is a pegmatite dike exposed as a broad lens along a ridge proven for a length of 250 yards and in places for a width of 100 feet. The strike is west, the dip 80° S. This dike is exposed by numerous shafts and tunnels and was carefully sampled and washed by the laboratory washing process, yielding 36 per cent of kaolin.

"The kaolin content has a refractory value above 1,730° C. Its color is grade 5. Its shrinkage when dried at 110° is 4.6 per cent and fired at 1,350° is 9.6 per cent. The tensile strength of the kaolin dried at 110° is 17 pounds per square inch.

Properties in standard porcelain mixture.

Tested in the mixture and fired at 1,350° C., this kaolin has a translucency of 0.68 and the transmitted light is yellow. Absorption is 3.6 per cent. The color is grade 5. The shrinkage at 110° C. is 3.6 per cent and at 1,350° C. 12.2 per cent. Tested under the fritted and raw-lead glazes the tint of the mass is unaltered.

SPRUCE PINE. TOLLEY MICA MINE.

"This mine is 1 mile southwest of Spruce Pine, Mitchell County, N. C., on the Spruce Pine-Burnsville road. The dike is exposed to a width of about 25 feet and from surface indications is approximately 10 feet wider. The material in the dike seems to be very uniform, no bands of wall rock being noted. Numerous stringers from this dike are exposed where it crosses the road 50 yards distant. This dike has been proven for 300 feet and is opened by a shaft claimed to have been originally 45 feet but now only 20 feet deep, and by a drift from this shaft at the 20-foot level. The drift runs 25 feet north, then turns and extends 7 feet to the west. The dike material in this dike seems very white but very sandy. The sample collected, when washed by the laboratory process, yielded 30 per cent kaolin.

"This has a chemical composition as follows:

Composition of kaolin.

H_2O	14.00
SiO_2	46.35
Al_2O_3	38.80
Fe_2O_3	.25
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
BaO	.03
Na_2O	Trace.
K_2O	.41
	99.84

"This kaolin has a refractory value above 1,730° C. Its color is grade 2. Dried at 110° C. it has a shrinkage of 5.4 per cent and fired at 1,350° C. shrinks 10.9 per cent. Dried at 110° C. the kaolin has a tensile strength of 8 pounds per square inch.

Properties in standard porcelain mixture.

This kaolin introduced into the mixture and fired at 1,350° C. has a translucency of 0.71 and the transmitted light is cream colored. Absorption is 7.3 per cent. Its color is grade 2. The mass when dried at 110° C. has a shrinkage of 3.4 per cent and when fired at 1,350° C. 14 per cent. Tested under the fritted and raw-lead glazes this mass acquires a very pale green tint, equally apparent under each glaze.

SPRUCE PINE. WISEMAN PROSPECT.

"This prospect is on Fort Creek, a branch of Three-Mile Creek, 3 miles north of Ingalls postoffice and 8 miles north of Spruce Pine, Mitchell County, N. C.

"The dike is ruptured by numerous intrusions, which at some points are stringers only a few feet wide; at others, form a single dike about 20 feet wide. The dike strikes N. 40° E. It varies in degree of kaolinization, but is remarkably free from impurities and is also very low in quartz. The workings consist of tunnels and shafts opened to expose the kaolin.

"All the exposed material of the main dike was sampled. Washed by the laboratory process, the sample averaged 37 per cent of kaolin. This kaolin has a refractory value above 1,730° C. The color when fired at 1,350° C. is grade 1. Dried at 110° C. this kaolin shrinks 7.4 per cent and fired at 1,350° C. it shrinks 17.4 per cent. It has a tensile strength of 17.5 pounds per square inch.

Properties in standard porcelain mixture.

This kaolin when introduced into the mixture and fired at 1,350° C. gives a translucency of 0.72. The transmitted light is cream colored. Absorption is 8.3 per cent. The color is grade 1. The kaolin, dried at 110° C., shrinks 4.4 per cent; when fired at 1,350° C., shrinks 14.4 per cent. The color is unaffected by the application of either the raw-lead or fritted glazes.

SPRUCE PINE. WISEMAN PROSPECT.

"This prospect is on the Marion road, 3 miles southeast of Spruce Pine, Mitchell County, N. C. The pegmatite dike, which is more or less kaolinized, has a northeast strike and a nearly vertical dip. The half adjoining the southeast wall is incompletely kaolinized, but kaolinization of the northwest half is well advanced. The entire deposit, however, is very sandy, as is common among kaolin deposits in this immediate vicinity. Adjoining this dike on the southeast side is a narrow ledge of coarse granite-pegmatite which is apparently unaltered.

"The kaolinized portion of this dike was sampled and tested with the following result:

"In the laboratory washing process it yielded 21 per cent of kaolin. The refractory value of the kaolin is 1,730° C. The color is grade 2. The shrinkage is 3.2 per cent when dried at 110°, and 11.9 per cent when fired at 1,350° C. When dried at 110° C. this kaolin has a tensile strength of 17 pounds per square inch.

Properties in standard porcelain mixture.

Tested in the mixture and fired at 1,350° C. this kaolin gives a translucency of 0.76 and the transmitted light is cream colored. Absorption is 3.7 per cent. The color is grade 2. The shrinkage when dried at 110° is 3.8 per cent, and when fired at 1,350° C., 13 per cent. The color under the fritted and raw-lead glazes is unaltered.

SYLVA. BUCHANAN PROSPECT.

"This prospect is 1½ miles east of Sylva and one-half mile south of the Murphy Branch of the Southern Railway in Jackson County, N. C.

"The dikes exposed vary in width from 10 to 18 feet, strike N. 40° E. and dip 80° N. One dike is exposed on or along a ridge that trends north. The overburden at the higher points averages from 2 to 10 feet, but downhill it averages from 15 to 20 feet. The dike at the higher elevation is exposed along the ridge and is one-eighth mile east of the other dike, hence the two are undoubtedly not a continuation of the same dike, although very similar as regards appearance and associated materials. In all of these dikes small lenses of garnet-colored sand mixed with altered biotite are found, but their removal under ordinary mining conditions would not cause any difficulty. The higher dike has been opened only by shallow pits, and the quality of the kaolin exposed is doubtless inferior to that obtainable at a little greater depth. The lower dike is well exposed by shafts 25 feet deep and by two tunnels and is of quite uniform structure and width.

"The lower dike was carefully sampled. Washed by the standard laboratory method the sample yielded 40 per cent of kaolin. This kaolin has a chemical composition as follows:

Composition of kaolin.

H_2O	13.77
SiO_2	46.30
Al_2O_3	39.06
Fe_2O_3	.20
TiO_2	.04
CaO	Trace.
MgO	Trace.
Na_2O	.11
K_2O	.60
	100.08

"This kaolin has a refractory value above 1,730° C. Its color is grade 3. Its shrinkage when dried at 110° is 5.4 per cent, and its total shrinkage at 1,350° C., 13.9 per cent. The tensile strength of this kaolin when dried at 110° is 28.5 pounds per square inch.

Properties in standard porcelain mixture.

This kaolin when introduced into the mixture and fired at 1,350° C. gives a translucency of 0.64 and the transmitted light is cream colored. Absorption

is 5.3 per cent. The color is grade 3. The shrinkage of the mass dried at 110° is 3 per cent; fired at 1,350° C., 13.1 per cent. Tested under the fritted and raw-lead glazes the mixture shows a pale green tint, which is equally apparent under each glaze.

SYLVA. FOREST HILL MICA MINE.

"This mine is on the Cox property 10 miles south of Sylva and 1 mile west of Cullowhee Creek in Jackson County, N. C.

"The dike has a general northeast strike and a vertical dip. It varies from 8 to 20 feet wide, and a number of stringers of great thickness are visible in the immediate neighborhood. Another dike is exposed by a shallow pit 100 yards to the north of this main dike but 50 feet below. An exposure of kaolin is also seen 1 mile south. The dike is in various stages of kaolinization, but is uniformly very free from impurities with the exception of a little quartz; no wide quartz bands were exposed by any of the numerous tunnels that have been driven in search of mica.

"The kaolin material was sampled by the laboratory washing process; it shows a kaolin content of 31 per cent. This kaolin has a chemical composition as follows:

Composition of kaolin.

H_2O	12.53
SiO_2	49.20
Al_2O_3	37.58
Fe_2O_3	.17
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
Na_2O	.13
K_2O	.47
	100.08

"This kaolin has a refractory value of 1,730° C. Its color when fired at 1,350° C. is grade 2. The shrinkage in drying at 110° is 4 per cent, and when fired at 1,350° C., 9.7 per cent. When dried at 110° this kaolin has a tensile strength of 16 pounds per square inch.

Properties in standard porcelain mixture.

In this mixture when fired at 1,350° C. the kaolin has a translucency of 0.73 and the transmitted light is cream colored. Absorption is 5.5 per cent. The color is grade 3. Dried at 110° C. the kaolin shrinks 1.4 per cent, and fired at 1,350° C., 11.6 per cent. When the fritted glaze or the raw-lead glaze is applied to this mixture the mass assumes a very pale green tint.

SYLVA. NORTH CAROLINA MINING AND MANUFACTURING COMPANY MINE.

"This mine is 2 miles south of Sylva, Jackson County, N. C., on the south slope of a mountain. The kaolinized pegmatite dike varies from 8 to 18 feet in width and strikes N. 45° E. There is a surface cut of about 200 feet, about 20 feet deep. From this level shafts have been sunk and material below has been removed. These shafts have been filled and their depth could not be determined, the surface indications only proving their existence. This mine is mentioned in Bulletin No. 13 of the North Carolina Geological Survey, which refers to numerous patches of partly kaolinized material in the dike, and states that several tons of fresh feldspar are reported to have been shipped.

"At only one point is the dike material now exposed. This material was sampled and washed and found to contain 26 per cent of kaolin.

"The analysis of this kaolin as given by the North Carolina Geological Survey is as follows:

Composition of kaolin.

Moisture	3.07
SiO_2	44.08
Al_2O_3	36.26
Fe_2O_3	1.86
CaO	.43
MgO	.20
KNaO	.50
Combined water	13.56
	99.96

"The general run of kaolin taken from this mine and washed by the standard laboratory process is doubtless much lower in iron than is indicated by this analysis, since the refractory value is above 1,730° C. and the color is grade 2. Dried at 110° C. it shrinks 5.7 per cent and fired at 1,350° C. 12.6 per cent. The tensile strength is 18 pounds per square inch.

Properties in standard porcelain mixture.

In this mixture fired at 1,350° C. the kaolin gives a translucency of 0.66 and the transmitted light is cream colored. Absorption is 6.1 per cent. The color is grade 2, and the shrinkage is 3.2 per cent dried at 110° C. and 13.3 per cent when fired at 1,350° C. Tested under the raw-lead and fritted glazes it shows a pale green tint, equally apparent under each glaze.

SYLVA. RODA KAOLIN AND MICA MINE.

"This mine is 7 miles southeast of Sylva, Jackson County, N. C., on the south side of the Tuckasegee River opposite the mouth of Caney Fork. The pegmatite dike cuts diagonally a low ridge and has a general northeast strike. A broad band of sugar quartz follows the south wall, which is very crooked. The extent of the dike has been proven more or less by test pits, but the chief exposure is by a long tunnel driven from the west slope of the hill. This tunnel passes through a broad band of low-grade pegmatite material into a band having a low quartz content. At this point a deep shaft has been sunk from the tunnel across its entire width and the portion of the tunnel beyond this point was inaccessible.

"The material in the neighborhood of the shaft, consisting of equal portions of the material rich in kaolin and material lean in kaolin, was sampled. Washed by the standard laboratory process the sample contained 26 per cent of kaolin. This kaolin has a refractory value above 1,730° C. Its color is grade 2. Its shrinkage dried at 110° C. is 4.1 per cent and fired at 1,350° C. is 12.7 per cent. The tensile strength is 21 pounds per square inch.

Properties in the standard porcelain mixture.

Introduced into the mixture and fired at 1,350° C. this kaolin gives a translucency of 0.66 and the transmitted light is cream-white. Absorption is 5.7 per cent. The color is grade 2. Dried at 110° C. the shrinkage is 3 per cent and fired at 1,350° C. is 12.2 per cent. Tested under the raw-lead and fritted glazes it shows a very pale green, equally apparent under both glazes.

TOECANE. P. H. HOWELL PROSPECT.

"This prospect is 3 miles southeast of Toecane, Mitchell County, N. C., and 1 mile southwest of the forks of Sink Hole road running to Young's Siding. The dike is on a high ridge along the crest and the general direction of the strike is N. 45° E. The dip is 80° NW. The width varies greatly, different exposures indicating a thickness of from 8 to 18 feet. The kaolinization of the pegmatite is well advanced, but the dike still contains some scattered semikaolinized lenses. The wall rock is a brown gneiss which differs distinctly in color from the Roan gneiss, which is the ordinary country rock throughout this district.

"The dike was sampled across its entire width. Washed by the standard laboratory process the sample yielded 31 per cent of kaolin.

The refractory value of this kaolin is 1,710° C. Its color is grade 2. Dried at 110° C. it shrinks 3 per cent; fired at 1,350° C. it shrinks 12.7 per cent. The tensile strength is 17 pounds per square inch.

Properties in standard porcelain mixture.

In the mixture and fired at 1,350° C. this kaolin has a translucency of 0.69 and the transmitted light is cream colored. Absorption is 5.9 per cent. The color is grade 2. The shrinkage dried at 110° C. is 3.4 per cent and fired at 1,350° C. is 13.1 per cent. Tested under the raw-lead and fritted glazes the mass shows a very pale green tint, equally apparent under each glaze.

WAYNESVILLE. KINSLAND MINE.

"This mine is on the Crabtree road, 9 miles northeast of Waynesville, Haywood County, N. C., just beyond the bridge over Pigeon River.

"The broad dike is divided into many sections by intruded material, but totals 75 feet in width. In one place where exposed by an old road, the general outline of the lenses of harder pegmatite and of wall rock are easily seen. The bands of kaolin material average from 6 to 8 feet wide and generally have a very high quartz content; the quartz is not in solid bands, but is scattered through the mass as small angular particles from one-eighth to one-half inch in size. The dike is opened by a number of shafts and tunnels, but most of them have caved badly. One of them still exposes the dike at a depth of about 20 feet where the kaolin, as in the road exposure, shows a rather excessive quartz content. This dike has a general strike N. 40° E. In addition to the exposures already mentioned there is an outcrop on the strike of this dike on a low hill 300 yards distant which shows the same general structure as this deposit.

"The kaolin in the shaft was carefully sampled. Washed by means of the laboratory apparatus, this sample contained 27 per cent of kaolin. This kaolin was analyzed; it has the following chemical composition:

Composition of kaolin.

H_2O	11.90
SiO_2	50.64
Al_2O_3	35.57
Fe_2O_3	.25
TiO_2	.03
CaO	Trace.
MgO	Trace.
BaO	.07
Na_2O	.08
K_2O	1.70
	100.24

"This kaolin has a refractory value of 1,670° C. Its color is grade 5. Its shrinkage at 110° C. is 4.4 per cent. Its shrinkage when fired at 1,350° C. is 9.8 per cent. Its tensile strength when dried at 110° is 8 pounds per square inch.

Properties in standard porcelain mixture.

Fired at 1,350° C. this kaolin in the mixture has a translucency of 0.76 and the transmitted light is cream colored. Absorption is 2.6 per cent. The color is grade 5. Dried at 110° the kaolin shrinks 1 per cent; fired at 1,350° C. it shrinks 13.6 per cent. Tested under the fritted and raw-lead glazes this porcelain mass remains unchanged in tint.

WEBSTER. COWAN PROSPECT.

"This prospect is one-half mile southeast of Webster, Jackson County, N. C., just west of the nickel-refining plant at that place. The test hole where the kaolinized material is exposed is near a small branch and the exposure is so small that no idea can be formed of the extent of the dike. The quality of the material, however, is high. No indications of kaolin or of pegmatite dikes are noted on the surface in the neighborhood of this exposure, but the overburden on the hillside is thick enough to hide them.

WEBSTER. HALL MINE.

"This mine is directly west of Webster, Jackson County, N. C., on a low ridge above Tuckasegee River and midway between Harris Bridge and Webster Bridge.

"The dike has several stringers which vary from 10 to 20 feet in width. It strikes N. 40° E., the dip being almost vertical. It is opened by a tunnel 60 feet long, which follows the strike, and a shaft about 20 feet deep. The shaft, however, has fallen in badly, so that samples could not be taken. The tunnel was sampled across the full width of the dike. The sample when washed yielded 24 per cent of kaolin. The refractory value of the kaolin is above 1,730° C. Its color is grade 4. Dried at 110° C. it shrinks 4.9 per cent, and fired at 1,350° C. it shrinks 12.4 per cent. The tensile strength is 18 pounds per square inch.

Properties in standard porcelain mixture.

In this mixture fired at 1,350° C. the kaolin has a translucency of 0.68 and the transmitted light is cream colored. Absorption is 4.6 per cent. The color is grade 4. The shrinkage of the kaolin dried at 110° C. is 3.1 per cent and fired at 1,350° C. is 13 per cent. Tested under the raw-lead and fritted glazes the color remains unaltered.

WEBSTER. LONG MICA MINE.

"This mine is one-fourth mile northeast of the mouth of Waychutta Creek and 4 miles southeast of Webster, Jackson County, N. C.

"The irregular pegmatite dike strikes N. 70° E. Mining has been entirely for mica, and two tunnels have been run into the hill, only one having been opened at the time of the visit. An open-cut directly above this tunnel exposes the surface of the dike. The width of this dike varies from 10 to 20 feet and is considerably broken by intrusions of wall rock. The dike is well advanced in kaolinization, but contains considerable streaked material similar to infiltrated surface stain.

"The richer part of the dike was sampled, care being taken to obtain material free from stain. The sample washed by the standard laboratory process yielded 35 per cent of kaolin. The refractory value of this kaolin is above 1,730° C. Its color is grade 2. Its shrinkage when dried at 110° C. is 4.1 per cent, and fired at 1,350° C. 11.2 per cent. The tensile strength is 20 pounds per square inch.

Properties in standard porcelain mixture.

In this mixture fired at 1,350° C. the kaolin has a translucency of 0.69 and the transmitted light is cream colored. Absorption is 6 per cent. The color is grade 2. The shrinkage when dried at 110° C. is 3 per cent and fired at 1,350° C. 13.8 per cent. Tested under the raw-lead and fritted glazes the kaolin shows a very pale green tint, equally apparent under each glaze.

WILLETTS STATION. WAYEHUTTA MICA MINE.

"This mine is on the west face of Black Mountain near the head of Wayehutta Creek and 3 miles south of Willetts Station, Jackson County, N. C.

"The irregular pegmatite dike strikes N. 70° E. and has a varying dip. The dike where exposed seems to be about 50 feet wide with a 10-foot horse of the wall rock near the center. A massive quartz band occurs along the south wall. The openings are four tunnels, only one of which penetrates kaolin material in commercial quantity. These tunnels are all on the steep slope of the ridge 300 feet or more above the road and 40 to 60 feet below its crest.

"The kaolin material was sampled. Washed by the standard laboratory method the sample yielded 33 per cent of kaolin. This kaolin has a refractory value above 1,730° C. Its color is grade 2. Dried at 110° C. it shrinks 4.6 per cent, and fired at 1,350° it shrinks 12.3 per cent. The tensile strength of the kaolin dried at 110° is 12.5 pounds per square inch.

Properties in standard porcelain mixture.

When tested in the mixture fired at 1,350° C. this kaolin has a translucency of 0.64 and the transmitted light is cream colored. Absorption is 7.1 per cent. The color of the porcelain mixture is grade 2. The shrinkage at 110° is 3.6 per cent and when fired at 1,350° C. 12.6 per cent. When tested under the fritted and raw-lead glazes no change of tint is noticeable.

ASSOCIATED MINERALS IN THE PEGMATITE DIKES.

OCHER.

AQUONE, N. C. YONCE FARM PROSPECT.

"Ocher is found on the Yonce farm 2 miles north of Aquone on Nantahala River, in Macon County, N. C.

"A deposit of this material is exposed in a creek bed for a width of about 15 feet. The dike strikes N. 35° E., and consists of four bands, of which a 4-foot band along the west wall and a 2-foot band along the east wall are very rich. The central portion of the dike is very sandy. No attempt has been made to develop this deposit, and no other exposures in either direction were found. A small deposit of similar material 100 yards east of this exposure is opened along a hillside, but from the associated material this is not believed to be the same body, although it may be a stringer from this body.

"The richest parts of this deposit were sampled and washed and yielded 42.5 per cent of high-grade golden ocher having the following composition:

Composition of ocher.

Volatile matter	13.59
SiO_2	15.40
Al_2O_3	16.25
Fe_2O_3	51.00
TiO_2	.30
	96.54

"Alkali and alkaline earths were not determined.

SPRUCE PINE, N. C. HARRIS CLAY COMPANY KAOLIN MINE.

"This mine is north of Spruce Pine, Mitchell County, N. C. The part of this deposit immediately below the overburden is a golden color in many places for a depth of 5 to 8 feet.

"This material was sampled and washed and found to contain 34 per cent of ocher. It contains much very fine mica, however, and must be washed with great care.

"Practically all the kaolin deposits in the Mount Mitchell district display this yellow material near the surface, and it may be washed to form a marketable product having a value equal to that of the kaolin.

SCHROETTERITE.

DILLSBORO, N. C. HARRIS CLAY COMPANY KAOLIN MINE.

"This mine is 5 miles southeast of Dillsboro, Jackson County, N. C. Associated with the kaolinized pegmatite found in this dike is a material similar to semikaolinized feldspar in appearance, but widely different in composition.

"This material occurs as small lenses or bands in the dike material and is reported as occurring at all levels, although its occurrence is noted oftenest at levels below 60 feet. Samples of this material show the following composition:

Composition of schroetterite.

H_2O	27.90
SiO_2	21.90
Al_2O_3	49.60
Fe_2O_3	.30
TiO_2	Trace.
CaO	Trace.
MgO	Trace.
K_2O	.10
Na_2O	.00
	99.80

"The composition approaches that of the mineral schroetterite, the formula of which is: $Al_{16}Si_3O_{30}.30H_2O$. This substance has a formula $Al_{16}Si_3O_{30}.25.4H_2O$, and differs from schroetterite in the amount of combined water only.

SUGAR QUARTZ.

"Sugar quartz is apparently of uniform quality wherever found, except that in some cases it is stained with infiltrated iron-bearing material or with incrustations of wad. If the quartz is to be used in the manufacture of pulverized flint that which is stained must be removed by hand.

"Samples of sugar quartz from numerous mines and prospects have been tested. An analysis of this material is as follows:

Analysis of sugar quartz.

SiO_2	99.32
Al_2O_3	.49
Fe_2O_3	Trace.
H_2O and organic	.10
	99.91

"Pulverized and fired, this material is a white powder that shows no bonding strength when heated to 1,350° C.

Properties in standard porcelain mixtures.

Introduced into the mixture this sugar quartz shows a translucency of 0.69 and has a pale yellow tint. The color is grade 5. The shrinkage when dried at 110° C. is 3.2 per cent; fired at 1,350° C. it is 16 per cent. Under the raw-lead and fritted glazes the color is unaltered.

WAD.

"In most of the kaolinized pegmatite dikes throughout the region investigated are nodules of wad scattered through the mass or incrusted in fissures in the quartz bands. Wad is an earthy manganese ore and carries some cobalt and other metal oxides. These nodules are found occasionally in the Gurney kaolin mines and are very abundant in the Isinglass Hill mica mine.

"Wad is found in nearly all other dikes examined as crusts in the crevices of the ruptured quartz bands. Samples of this material have been taken and its identity established by determinative mineralogy methods.

"In the kaolin mine of the Southern Clay Company, 1 mile northwest of Franklin, Macon County, N. C., a large amount of this material was found, which was sampled and analyzed. The chemical composition is as follows:

Composition of nodule of wad.

Volatile matter	15.30
SiO_2	33.20
Al_2O_3	24.60
Fe_2O_3	4.00
TiO_2	.25
Mn_3O_4	21.80
$CaO+NiO$	.75
CuO	.50
	100.40"

FELDSPAR.

Although it has been known for a good many years that North Carolina contains deposits of feldspar suitable for use in the manufacture of pottery, yet it was only within the past few years that these have become commercially available, this being due to the construction of the C., C. and O. Railway through Mitchell and Yancey counties. The first production of feldspar was in 1911, by the Carolina Mineral Company, from a quarry located near Penland. They increased their production in 1912, but were still the only producer of this mineral in this State. Prospecting and development work have been carried on in several localities in Mitchell and Yancey counties, and there will undoubtedly be a considerable increase in the production of this mineral in following years. As there was only one producer of feldspar during the past two years, the production is included under the head of "Miscellaneous Minerals."

The feldspar produced was used for pottery, enameling, dentistry, etc., and smaller amounts were used in the manufacture of corundum and emery wheels, the feldspar being used as a binder for the grains of corundum and emery. The first grade of feldspar is white to a slightly flesh-color, with the following composition:

Analysis of feldspar from Penland.[1]

	Per cent
Potash, (K_2O)	13.40
Lime, (CaO)	.10
Magnesia, (MgO)	.10
Oxide of Iron, (Fe_2O_3)	.70
Alumina, (Al_2O_3)	21.51
Silica, (SiO_2)	64.20
	110.01

KAOLIN.

During 1911 and 1912 kaolin was obtained from Mitchell, Macon, Jackson, and Swain counties, given in the order of the importance of their production, which was the same for each year.

As was stated on page 182, an investigation has recently been made of the kaolin deposits of North Carolina, and a description of this investigation is given in connection with feldspar, on pp. 182-292, inclusive.

In a great many of the kaolin deposits there is more or less mica, some of which is obtained in the form of "blocks" and "books" of com-

[1] E. F. Johnson, Chemist, New York.

mercial value. There is considerable mica in the kaolin in the form of fine particles, which is washed out during the process of preparing the kaolin for market. The question has been raised whether or not this material would not have sufficient commercial value to warrant its being saved.

PRODUCTION.

The production of kaolin in 1911 was 14,903 tons, valued at $130,610, and in 1912 it was 14,950 tons valued at $109,717. There is given in the table below the production of kaolin in North Carolina for the years 1900-1912 inclusive:

Production of Kaolin in North Carolina from 1900-1912, Inclusive.

Year.	Amount.	Value.
	Tons.	
1900	7,000	$ 62,440
1901	15,575	119,172
1902	13,322	108,105
1903	8,605	76,000
1904	9,110	76,670
1905	10,988	85,622
1906	10,803	90,036
1907	11,035	85,505
1908	10,532	85,300
1909*	12,097	99,174
1910*	14,080	119,040
1911	14,903	130,610
1912	14,950	109,717

*Contains small amount of fire clay.

PRODUCERS.

The following were the producers of kaolin during 1911-1912:
The Gurney Clay Company, Franklin, N. C.
F. R. Hewitt, Kaolin Company, Almond, N. C.
Harris Clay Company, Dillsboro, N. C.
Southern Clay Company, East Liverpool, Ohio.

CLAY AND CLAY PRODUCTS.

With the exception of kaolin, all of which is shipped out of the State, there is but little clay which is mined and put on the market as a raw product. The bulk of the value of clay products given in the table on "Mineral Production" represents the value of the products manufactured

from the clay, and of these manufactured products, common brick represent by far the largest value. In 1912 the number of common brick reported as having been produced was 193,058,000, which is the greatest quantity produced in this State in any one year. While many of the manufacturers of common brick have improved their methods, so that each year there is a greater and greater number of better quality common brick put on the market, yet there is still room for improvement in the methods of manufacture of this type of brick amongst the great number of producers.

With the production of feldspar in Western North Carolina and the abundance of quartz that exists in that same section suitable for pottery purposes, the Geological Survey wishes again to call attention to the opening that there is in this State for one or more pottery establishments which will utilize the kaolin and feldspar now being shipped out of the State.

PRODUCTION.

There is given in the following tables the total production of clay products in North Carolina for the years 1904-1912, inclusive:

Value of Clay Production of North Carolina from 1904 to 1912.

	1904.		1905.		1906.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Common brick	143,988,850	$ 795,494	153,610,000	$ 896,289	166,338,000	$ 1,041,078
Pressed brick	1,510,000	17,375	875,000	13,925	385,000	4,410
Vitrified brick	430,000	3,850	400,000	3,600	400,000	4,000
Fire brick	163,000	2,700	681,000	8,333	401,000	7,180
Earthenware		438		387		713
Stoneware		13,462		12,932		11,057
Sewer pipe, tile, etc.		110,800		102,445		113,900
	Tons.		*Tons.*		*Tons.*	
Kaolin	9,110	76,670	10,988	85,622	10,803	90,036
Fire clay	*202	761	*107	519	207	322
Total values		1,021,550		1,124,052		1,272,696

Value of Clay Production of North Carolina from 1904 to 1912—Cont.

	1907.		1908.		1909.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Common brick	174,750,000	$1,150,185	143,892,000	$ 900,611	188,313,000	$ 1,140,727
Pressed brick	770,000	7,925	300,000	2,700	725,000	9,250
Vitrified brick	150,000	1,500	50,000	400		
Fire brick	194,000	3,490	700,000	7,560		
Earthenware		2,382		775		1,780
Stoneware		7,840		12,587		16,929
Sewer pipe, tile, etc.		142,000		19,335		133,925
	Tons.		*Tons.*		*Tons.*	
Kaolin	11,035	85,505	10,532	85,300	12,097	99,174
Fire clay	*903	986	2,298	349		
Total values		1,401,813		1,029,617		1,401,785

*Including ordinary stoneware clay sold crude.

	1910.		1911.		1912.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Common brick	167,966,000	$1,039,319	178,235,000	$1,076,183	193,058,000	$ 1,236,443
Front brick	550,000	5,800	793,000	7,783	1,131,000	10,085
Vitrified brick						
Fire brick			130,000	1,800	324,000	4,430
Earthenware		1,961		1,333		778
Stoneware		13,029		7,223		8,172
Sewer pipe, tile, etc.		163,555		185,804		205,745
	Tons.		*Tons.*		*Tons.*	
Kaolin	14,080	119,040	14,903	130,610	14,950	139,717
Fire and pipe clays					20	104
Total values		1,342,704		1,410,736		1,605,474

As has been stated above, these tables probably do not represent the total output of clay products throughout the State, for the reason that in a number of the counties there were a few thousand brick made for local purposes, regarding which it is extremely difficult or impossible to obtain statistics. This is especially true where the brick are not for sale, but are for use by the manufacturer; and it may be a year or more before he manufactures any more.

POTTERY CLAY.

Although North Carolina has a comparatively large number of active potters reporting a production of pottery products—there being 19 in 1911 and 21 in 1912 who reported a production—yet the industry is of little importance as compared with the pottery industry of the country. The total value of the pottery of this State in 1911 was $8,556, and in 1912, $8,950, an increase of $394. Red earthenware and stoneware were the only grades of pottery produced.

PRODUCTION.

In the table below there is given the value of the pottery production for North Carolina by counties for the years 1907-1912, inclusive:

Value of the Pottery Products of North Carolina by Counties from 1907 to 1912, Inclusive.

County.	1907.			1908.			1909.		
	Earthenware.	Stoneware.	Total.	Earthenware.	Stoneware.	Total.	Earthenware.	Stoneware.	Total.
Buncombe	$ 150	$2,184	$2,334	$ 75	$1,870	$1,945	$ 270	$3,260	$ 3,530
Catawba	1,392	1,800	3,192	145	4,460	4,605	1,080	6,980	8,060
Chatham				100	50	150	*		
Johnston	100		100		2,142	2,142	355	4,639	4,994
Lincoln	100	1,100	1,200		925	925			
Moore				60	300	360	†		
Randolph	435	1,496	1,931	255	1,590	1,845	‡		
Union	165	750	915	140	1,250	1,390	†		
Wilkes	40	510	550				75	2,050	2,125
Totals	2,382	7,840	10,222	775	12,587	13,362	1,780	16,929	18,709

County.	1910.			1911.			1912.		
	Earthenware.	Stoneware.	Total.	Earthenware.	Stoneware.	Total.	Earthenware.	Stoneware.	Total.
Buncombe	$ 630	$ 400	$1,030	$ 400	$ 350	$ 750	$ 210	$1,490	$ 1,700
Catawba	821	7,184	8,005	180	1,860	2,040	193	2,682	2,875
Johnston									
Lincoln	25	1,560	1,585	42	1,888	1,930	20	1,550	1,570
Montgomery									
Moore	300	400	700	425	400	825	286	1,114	1,400
Randolph	120	1,760	1,880	236	1,205	1,441	69	146	215
Union		300	300		400	400		300	300
Wilkes	65	1,425	1,490	50	1,120	1,170		890	890
Totals	1,961	13,029	14,990	1,333	7,223	8,556	778	8,172	8,950

*Included with Buncombe. †Included with Wilkes. ‡Included with Lincoln.

The following table shows the total value of the pottery production in North Carolina for the years 1900-1912, inclusive:

Production of Pottery in North Carolina, 1900-1912.

Year.	Value of Pottery.
1900	$ 18,863
1901	22,495
1902	14,512
1903	14,312
1904	13,900
1905	13,319
1906	11,770
1907	10,222
1908	13,362
1909	18,709
1910	14,990
1911	8,556
1912	8,950

PRODUCERS.

Those producing pottery during the years 1911-1912 are given below:

Reems Creek Pottery Works, George B. Donkel, proprietor, Brankton, Buncombe County.

Hominy Pottery Company, A. M. Fulbright, proprietor, Candler, Route 2, P. O. Box No. 30, Buncombe County.

W. M. Penland, Candler, Buncombe County.

Buncombe County Ceramic Company, Candler, Buncombe County.

Weaverville Pottery, James R. Cheek, proprietor, Weaverville, Buncombe County.

W. H. Blackburn, Blackburn, R. F. D. No. 1, Catawba County.

Robert D. Ritchey, Henry, R. F. D. No. 2, Catawba County.

Wade D. C. Johnson, Henry, R. F. D. No. 2, Box No. 57, Catawba County.

J. A. Propst & Son, Henry, R. F. D. No. 2, Catawba County.

R. P. Speagle, Jugtown, R. F. D. No. 1, Catawba County.

Royal Stallings, Jugtown, Catawba County.

Kilby & Baker, Newton, R. F. D. No. 1, Catawba County.

Oak Grove Pottery Works, Phillips Bros., proprietors, Newton, R. F. D. No. 1, Catawba County.

W. T. Brackett, Henry, R. F. D. No. 2, Lincoln County.

M. L. Leonard, Henry, R. F. D. No. 1, Lincoln County.

Reinhardt Bros., Henry, R. F. D. No. 3, Catawba County.

Henry W. Chriscoe, Steeds, R. F. D., Moore County.
John W. Teague, Steeds, R. F. D., Moore County.
Ruffin Cole, Seagrove, Randolph County.
L. Owen & Son, Steeds, Randolph County.
James C. Broom, Monroe, R. F. D. No. 10, Union County.
Wilkesboro Pottery Works, B. J. Kennedy, proprietor, Wilkesboro, Wilkes County.

FIRE CLAY AND PIPE CLAY.

There is included under this head fire and pipe clays and shales, and products manufactured from them, such as fire brick, sewer pipe, drain tile, fancy tile, flue lining, terra cotta, etc. The greater portion of the production of these clays and shales is from Guilford County. Recently there has been an investigation of a shale in Madison County, and a company has organized to develop a property and erect a plant for manufacturing fire and face brick, roofing, tile, etc.

PRODUCTION.

There is given in the table below the production of fire clay, shale, and pipe clay, and the products manufactured from them for the years 1901-1912, inclusive:

Production of Fire Clay and Clay Products in North Carolina, 1901-1912.

Year.	Fire Brick.		Sewer Pipe, Tile, etc.	Crude Clay.	
	Quantity.	Value.		Tons.	Value.
1901	55,000	$ 550	$ 55,745		$ 100
1902		1,203	72,618		215
1903	407,500	5,250	100,989	231	875
1904	163,000	2,700	110,800	80	700
1905	681,000	8,333	102,445	57	494
1906	401,000	7,180	113,900	19	185
1907	194,000	3,490	142,000	903	986
1908	700,000	7,560	19,335	2,298	349
1909			133,925		753
1910			163,555	80	40
1911	130,000	1,800	185,804	81	56
1912	324,000	4,430	205,745	20	104

PRODUCERS.

It is interesting to note the sudden increase in the production of this type of clay products. As is noted from the above, but a very small amount of the crude clay is put on the market. Those producing these clays and manufacturing products from them during 1911 and 1912 were as follows:

Mrs. M. F. Clinton, Weaverville, N. C., Buncombe County.
E. C. Cole, Candler, Buncombe County.
Dillard F. Gudger, Candler, Buncombe County.
C. H. Rhodes, Lincolnton, R. F. D. No. 2, Lincoln County.

In the table below there is given the quantity and value of common, front, vitrified, and fire brick, produced in North Carolina from 1909 to 1912, inclusive:

Production of Common, Pressed, Vitrified, and Fire Brick in 1909-1912, Inclusive.

Character of Brick.	1909.		1910.		1911.		1912.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Common	188,313,000	$1,140,727	167,966,000	$1,039,319	178,235,000	$1,076,183	193,058,000	$1,236,443
Front			550,000	5,800	793,000	7,783	1,131,000	10,085
Vitrified	725,000	9,250						
Fire					130,000	1,800	324,000	4,430
Totals	189,038,000	$1,149,977	168,516,000	$1,045,119	179,158,000	$1,085,766	194,513,000	$1,250,958

BRICK CLAY.

The production of the various types of brick that were manufactured from brick clay, such as common brick, pressed brick, fancy brick, etc., is dependent largely upon the demand for builders' materials. During the past two years there has been a constant increase in the amount of building that has been going on, with the result that there has been a large increase in the production of brick in North Carolina, this being especially true of common brick. There is still imported into North Carolina a large quantity of brick, which is due partly to the inferior quality of many of the common brick that are put on the market in North Carolina. As stated elsewhere, a great many of the manufacturers have the most improved methods of manufacturing brick, and it is very gratifying to note that the production of these producers has been very largely increased during the past two years, and that they are receiving a much better price for their brick; while, on the other hand, the price received by those who are not making good quality brick is decreasing.

PRODUCTION.

In 1911 there were 178,235,000 common brick produced, valued at $1,076,183, which is an average of $6.04 per thousand. In 1912 there were 193,058,000 common brick produced, valued at $1,236,443, or an average value of $6.40 per thousand; and in 1911 the front brick

amounted to 793,000, valued at $7,783, and in 1912 to 131,000, valued at $10,085. There was but a small quantity of vitrified and fire brick produced each year.

The next table gives the number and value of common brick manufactured in North Carolina by counties for the years 1911-1912, inclusive. Where there were less than three producers in a county, they are combined in groups. Wayne County was the largest producer of common brick in both 1911 and 1912, when its productions were 12,750,000 and 23,600,000 respectively. The county reporting the smallest production of brick in 1911 was Greene and in 1912 Macon and Duplin counties produced the same number of brick.

Number and Value of Common Brick Made in North Carolina During 1911-1912, by Counties.

County.	1911.		1912.	
	Number Common Brick.	Value.	Number Common Brick.	Value.
Alamance	3,400,000	$ 20,450	4,550,000	$ 28,400
Anson, Beaufort, Bertie, Buncombe, Burke, Cabarrus, Caldwell, Camden, Catawba, Chatham, Chowan, Cleveland, Columbus	5,129,000	31,735	6,010,000	27,027
	10,100,000	65,950	9,030,000	56,150
	3,900,000	21,725	4,181,000	25,886
	3,195,000	21,270	4,085,000	26,925
Craven	6,965,000	36,344	8,347,000	49,560
Cumberland	5,500,000	34,050	5,000,000	33,250
Davidson, Davie, Duplin	2,355,000	17,220	485,000	3,405
Durham	4,257,000	28,735	5,430,000	38,840
Edgecombe	2,050,000	12,850	2,655,000	18,410
Forsyth	6,968,000	44,017	7,180,000	45,748
Gaston	1,000,000	6,000	2,900,000	20,217
Granville	1,100,000	7,800	700,000	6,272
Greene*				
Guilford	9,430,000	53,925	10,320,000	63,462
Halifax	12,511,000	76,292	7,250,000	47,550
Harnett*				
Henderson	10,000,000	54,500	9,600,000	53,500
Iredell*	1,949,000	12,836	2,358,000	17,290
Johnston	4,050,000	24,175	4,290,000	28,550
Lee, Lenoir, Lincoln	1,100,000	6,500	1,150,000	7,200

Number and Value of Common Brick Made in North Carolina During 1911-1912, by Counties.

County.	1911.		1912.	
	Number Common Brick.	Value.	Number Common Brick.	Value.
Macon, Madison, Martin	785,000	$ 4,710	1,535,000	$ 10,405
Mecklenburg	8,100,000	47,500	7,000,000	45,000
Montgomery	1,900,000	12,100	1,800,000	11,875
Moore, Nash, New Hanover, Onslow, Orange, Pasquotank	5,300,000	35,800	8,100,000	61,200
Pender	3,100,000	16,500	3,100,000	18,000
Perquimans	†			
Pitt	4,900,000	32,500	5,500,000	36,800
Randolph	2,100,000	12,651	2,150,000	14,500
Robeson, Rockingham	† 3,350,000	23,255	3,451,000	23,184
Rowan, Rutherford, Sampson	5,650,000	34,460	6,410	42,500
Stanly, Stokes	8,656,000	52,158	9,291,000	57,300
Surry	2,300,000	12,550	980,000	5,500
Union	7,000,000	41,350	4,500,000	30,200
Wake	9,900,000	56,750	12,000,000	69,000
Washington	‡			
Watauga	‡			
Wayne	12,750,000	72,150	23,600,000	161,400
Wilkes, Wilson, Yadkin	‡4,835,000	29,175	5,370,000	33,487
Totals	178,235,000	$ 1,076,183	193,058,000	$ 1,236,443

*Production of Greene and Harnett counties included.
†Perquimans included with Robeson and Rockingham.
‡Washington and Watauga included with Wilkes, Wilson and Yadkin.

PRODUCERS.

The following were the principal brick and tile producers during 1911 and 1912:

Kirkpatrick Bros., Burlington, Alamance County.
Parks & Jeffreys, Graham, Alamance County.
Trollinger & Montgomery, Haw River, Alamance County.
Mebane L. Stuart, Graham, Alamance County.
Polkton Brick Company, Polkton, Anson County.
Wadesboro Brick and Lumber Company, Wadesboro, Anson County.

Pamlico Brick and Tile Company, Washington, Beaufort County.
Carolina Building and Hardware Company, Aulander, Bertie County.
Shiloh Brick and Tile Company, Shiloh, Camden County.
George C. Shehan Brick Company, West Asheville, R. F. D. 1, Buncombe County.
G. P. Jones, Candler, Buncombe County.
Abernethy, Lyerly & Co., Bridgewater, Burke County.
Morganton Brick Company, Morganton, Burke County.
R. A. Brown's Construction Company, No. 1, Concord, Cabarrus County.
Mount Pleasant Brick Company, Mount Pleasant, Cabarrus County.
Powell Bros. Brick Company, Lenoir, Caldwell County.
Granite Falls Brick Company, Granite Falls, Caldwell County.
Hickory Brick Company, Hickory, Catawba County.
L. W. Poovey Brick Company, Brookford, Catawba County.
E. M. Deal, Newton, Catawba County.
C. N. Bray & Bro., Siler City, Chatham County.
Edenton Brick Works, Edenton, Chowan County.
Kendrick Bros., Cherryville, Cleveland County.
J. A. Falls, Kings Mountain, Cleveland County.
Oscar High, Whiteville, Columbus County.
Clark Brick and Tile Company, Clark, Craven County.
Enterprise Brick, Tile and Manufacturing Company, New Bern, Craven County.
Carolina Brick Company, Kinston, Lenoir, Martin and Craven counties.
New Bern Brick Company, New Bern, Craven County.
Vance Bros., Vanceboro, Craven County.
Cape Fear Brick Company, Wade, Cumberland County.
E. A. Poe Brick Company, Fayetteville, Cumberland County.
Tar Heel Brick Company, Wade, Cumberland County.
Fire Stone Brick Company, Lexington, Davidson County.
E. J. Kennedy, Thomasville, Davidson County.
P. B. Cain, Knoxville, Davie County.
Dennis Lanier, Chinquapin, Duplin County.
Luther and R. H. Maready, Chinquapin, Duplin County.
Cheek & Belvin, Durham, Durham County.
R. H. Clegg, Durham, Durham County.
B. W. Mangum, Durham, Durham County.
M. L. Teer, Durham, R. F. D. No. 6, Durham County.

J. T. Fowler, Durham, Durham County.
Walton Brick Company, Macclesfield, Edgecombe County.
Rougemont Brick Company, Roxboro, Person County.
Rocky Mount Brick Company, Rocky Mount, Edgecombe County.
George Howard Hardware Company, Tarboro, Edgecombe County.
Winston Brick and Tile Company, Winston-Salem, Forsyth County.
Adrian L. Dean, Kernersville, Forsyth County.
R. F. Byerly & Co., Winston-Salem, Forsyth County.
R. W. Hedgecock, Winston-Salem, Forsyth County.
B. X. and R. F. Linville, Kernersville, R. F. D. No. 4, Forsyth County.
R. L. Whitfield & Co., Winston-Salem, Forsyth County.
Gaston Brick Company, Charlotte, N. C., Gaston County.
Thompson Brick Company, Cherryville, Gaston County.
Suggs & Davis, Gastonia, Gaston County.
Lowell Brick and Ginning Company, Lowell, Gaston County.
Creedmoor Planing and Brick Company, Creedmoor, Granville County.
Colored Orphan Asylum, Oxford, Granville County.
G. W. Jones, Snow Hill, Greene County.
W. O. Atkins Brick Company, Colfax, Guilford County.
Dillon & Atkins, Kernersville, Guilford County.
G. W. Alley, Greensboro, Guilford County.
P. W. Clark, Asheboro Street, Greensboro, Guilford County.
W. G. Jennings & Son, Greensboro, Guilford County.
James M. Smith, Greensboro, Guilford County.
Cunningham Brick Company, Greensboro, Guilford County.
A. W. Watson Brick Company, Bragg Street, Greensboro, Guilford County.
J. G. Williams, Greensboro, Guilford County.
High Point Brick Company, High Point, Guilford County.
Pomona Terra Cotta Company, Pomona, Guilford County.
Hobgood Brick and Building Company, Hobgood, Halifax County.
J. W. Madry, Scotland Neck, Halifax County.
Chockoyotte Brick Company, Weldon, Halifax County.
Roanoke Brick Company, Weldon, Halifax County.
Weldon Brick and Land Improvement Company, Weldon, Halifax County.
Buies Creek Improvement Company, Buies Creek, Harnett County.
D. S. Hildebrand, Asheville; works, Henderson County.

Asheville Brick and Tile Company, Fletcher, Henderson County.
J. C. Sherrill, Hendersonville, Henderson County.
Carpenter & Cloanager, Mooresville, Iredell County.
L. C. Hudson, Mooresville, Iredell County.
Statesville Brick Company, Statesville, Iredell County.
G. S. Cable, Clayton, Johnston County.
Selma Brick Company, Selma, Johnston County.
Sanders & Walton, Smithfield, Johnston County.
Jonesboro Brick Company, Jonesboro, R. F. D. No. 1, Lee County.
Moseley Brick and Shingle Company, Kinston, Lenoir County.
B. S. Mauney Brick Company, Lincolnton, Lincoln County.
Franklin Brick Company, Franklin, Macon County.
J. R. Anderson, Mars Hill, Madison County.
Martin County Brick and Tile Company, Williamston, Martin County.
Queen City Brick Company, Charlotte, Mecklenburg County.
Charles F. Smith, Cornelius, Mecklenburg County.
Carson Brick Company, Charlotte, Mecklenburg County.
J. R. Comer, Asbury, Montgomery County.
O. E. Rich, Star, Montgomery County.
Troy Brick Company, Troy, Montgomery County.
W. M. Kivett, Carthage, Moore County.
W. C. Leslie & Co., Vass, Moore County.
Tar River Brick Company, Rocky Mount, Nash County.
Roger Moore's Sons & Co., Wilmington, New Hanover County.
Richlands Brick Company, Richlands, Onslow County.
Hillsboro Brick Manufacturing Company, Hillsboro, Orange County.
Elizabeth City Brick Company, Elizabeth City, Pasquotank County.
W. H. Booth, Atkinson, Pender County.
Burgaw Brick Works, Inc., Burgaw, Pender County.
Union Brick and Tile Company, Burgaw, Pender County.
White & Knowles, Hertford, Perquimans County.
W. J. Gardner & Sons, Bethel, Pitt County.
R. E. Belcher, Farmville, Pitt County.
Greenville Brick Manufacturing Company, Greenville, Pitt County.
Foust & Brown, Asheboro, Randolph County.
Glenola Brick Company, Glenola, Randolph County.
Liberty Brick Company, Liberty, Randolph County.
B. W. Walden, Randleman, Randolph County.
Acme Brick Company, Lumberton, Robeson County.

Bracey Bros. Brick Company, Rowland, Robeson County.
Martin-Harrell & Bro., St. Pauls, Robeson County.
J. M. Hopper, Leaksville, Rockingham County.
James A. Foust & Son, Madison, Rockingham County.
Noah Winecoff, Bear Poplar, Rowan County.
J. C. Lyerly, Rockwell, Rowan County.
Isenhour Brick Company, Salisbury, Rowan and Stanly counties.
Martin D. Hill, Rutherfordton, R. F. D. No. 2, Rutherford County.
D. J. Bedsole, Roseboro, Sampson County.
J. B. Bryan, Roseboro, Sampson County.
Yadkin River Brick Yard, New London, Stanly County.
Consolidated Brick and Tile Company, Pine Hall, Stokes County.
Hedgecock Brick Company, Walnut Cove, Stokes County.
Poindexter & Madison, Elkin, Surry County.
W. E. Merritt, Mount Airy, Surry County.
C. C. Midkiff, Mount Airy, R. F. D. No. 2, Surry County.
Mount Airy Brick Company, Mount Airy, Surry County.
Marshville Brick Company, Marshville, Union County.
H. T. Pate, Monroe, Union County.
J. T. Shute, Monroe, Union County.
W. W. Phifer & Bro., Stout, Union County.
L. J. Johnston, Apex, R. F. D. No. 3, Wake County.
Johnson & Johnson Company, Raleigh, Wake County.
Raleigh Brick Company, Raleigh, Wake County.
Plymouth Brick and Tile Manufacturing Company, Plymouth, Washington County.
Joe P. Church, Hackett, Watauga County.
Borden Brick and Tile Company, Goldsboro, Wayne County.
Goldsboro Brick Works, Goldsboro, Wayne County.
H. Weil & Bros., Goldsboro, Wayne County.
W. H. Waugh & Co., North Wilkesboro, Wilkes County.
Lucama Brick Company, Wilson, Wilson County.
Sharpsburg Brick Company, Sharpsburg, Wilson County.
Wilkins Construction Company, Wilson, Wilson County.
S. H. Joyner & Sons, Yadkinville, Yadkin County.

SUMMARY.

There is given in the table below the value of the mineral production in each county in North Carolina for the years 1909-1912, inclusive:

Value of Mineral Production of North Carolina During 1909-1912, Including Clay Products.

County.	Total Value of Mineral Production.			
	1909.	1910.	1911.	1912.
Alamance	$ 33,900	$ 35,520	$ 20,450	$ 28,400
Alexander	1,398	750	1,325	624
Alleghany	400	500	500	300
Anson	5,850	13,100	83,775	7,104
Ashe	155	500	4,000	5,300
Avery			149,369	186,264
Beaufort	26,923	21,790	25,290	16,048
Bertie(a)		a	8,110	10,527
Bladen		a		
Brunswick				
Buncombe	82,844	64,505	60,777	75,114
Burke	23,285	16,263	10,417	14,104
Cabarrus	21,796	21,229	36,569	23,735
Caldwell	17,800	6,865	7,300	16,386
Camden(b)	b		1,890	
Carteret				
Caswell				
Catawba	35,695	25,146	21,879	12,510
Chatham	2,600	13,480	1,600	6,250
Cherokee	31,283	22,325	19,528	33,134
Chowan(b)		b	8,400	8,400
Clay				1,200
Cleveland	39,273	18,059	19,770	15,429
Columbus	10,081	3,550	6,100	7,500
Craven	52,371	48,916	50,794	59,150
Cumberland	26,145	29,621	34,079	33,316
Currituck				
Dare				
Davidson	2,353	145	15,000	34,271
Davie	2,560	8,200	1,300	1,400
Duplin(c)		c	920	80
Durham	41,794	40,558	30,735	41,040
Edgecombe	25,362	17,073	12,850	18,410
Forsyth	54,648	45,659	44,431	45,893
Franklin	39	1,041	811	1,228
Gaston	14,583	16,034	13,015	27,756
Gates				
Graham				
Granville	48,342	19,170	8,400	14,869
Greene		1,500	350	
Guilford	190,415	197,404	237,415	273,150
Halifax	47,064	35,550	78,292	58,933
Harnett	2,678	1,600	800	1,500
Haywood	1,550	7,075	4,300	5,912
Henderson	99,480	60,882	81,952	98,417
Hertford		3,000		
Hoke				
Hyde				
Iredell	27,736	12,949	15,394	24,466
Jackson	51,599	53,804	22,387	63,413
Johnston	33,062	21,458	24,175	28,550

Value of Mineral Production of North Carolina During 1909-1912, Including Clay Products—Continued.

County.	Total Value of Mineral Production.			
	1909.	1910.	1911.	1912.
Jones	$ 12	$ 1,050	$ 1,000	$ 15,100
Lee	7,694	5,200	12,085	2,950
Lenoir	*d*	7,136	2,500	6,000
Lincoln	12,092	3,807	3,555	3,295
McDowell	2,850	14,594	712	615
Macon	45,732	50,300	102,122	91,300
Madison	21,785	20,824	16,668	12,400
Martin	5,436	5,347	3,210	8,125
Mecklenburg	63,701	80,678	88,806	105,817
Mitchell	191,777	259,127	198,483	238,192
Montgomery	8,692	62,306	68,284	162,501
Moore	16,200	27,470	18,149	41,901
Nash	18,081	13,500	13,000	21,000
New Hanover	59,138	48,250	36,578	40,839
Northampton				
Onslow			2,100	350
Orange	27,972		8,400	10,500
Pamlico				
Pasquotank	*e*	25,900	5,700	7,600
Pender	18,200	*h*	16,500	18,000
Perquimans	*e*		2,500	4,000
Person		17,450		
Pitt	28,512	26,070	32,500	36,800
Polk	5,930	19,045	6,803	10,338
Randolph	16,403	21,703	14,306	15,320
Richmond				
Robeson	9,234	16,227	17,225	17,634
Rockingham	310,784	47,750	44,268	51,839
Rowan	178,984	397,930	273,925	382,571
Rutherford	20,857	3,125	626	5,315
Sampson	4,723	1,900	3,500	6,300
Scotland		8,100		
Stanly	12,263	12,032	16,000	19,640
Stokes	49,552	53,504	43,588	42,890
Surry	166,394	278,728	392,674	422,227
Swain	99,564	80,983	55,266	46,318
Transylvania	7,337	6,770	2,310	2,800
Tyrrell				
Union	52,003	45,300	42,479	31,004
Vance	75,396	17,220	23,750	21,890
Wake	63,308	69,155	56,750	74,250
Warren	*f*	54,344	26,800	25,757
Washington			750	12,000
Watauga	*g*	*i*		212
Wayne	46,338	59,810	76,152	165,794
Wilkes	6,685	6,536	3,680	6,400
Wilson	40,716	34,350	28,125	16,375
Yadkin	812	420	3,300	
Yancey	32,660	59,284	4,300	10,650
Unknown	945			
Totals	$ 2,783,826	$ 2,848,446	$ 2,933,878	$ 3,514,892

*a*Included with Beaufort County. *b*Included with Caldwell County. *c*Included with Durham County. *d*Included with Lee County. *e*Included with Orange County. *f*Included with Vance County. *g*Included with Wayne County. *h*Included with Pasquotank County. *i*Included with Warren County.

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Administrative report. Contains Special Report on an examination of the Sand Banks along the North Carolina Coast, by Jay F. Bond, Forest Assistant, United States Forest Service; certain magnetic observations at North Carolina stations; Results of an Investigation Relating to Clam Cultivation, by Howard E. Enders of Purdue University.

Biennial Report, 1909-1910, Joseph Hyde Pratt, State Geologist, 1911. 8°, 152 pp. *Postage 10 cents.*

Administrative report and contains Agreements for Coöperation in Statistical Work, and Topographical and Traverse Mapping Work with the United States Geological Survey; Forest Work with the United States Department of Agriculture (Forest Service); List of Topographic maps of North Carolina and counties partly or wholly topographically mapped; description of special Highways in North Carolina; suggested Road Legislation; list of Drainage Districts and Results of Third Annual Drainage Convention; Forestry reports relating to Connolly Tract, Buncombe County and Transylvania County State Farms; certain Watersheds; Reforestation of Cut-over and Abandoned Farm Lands on the Woodlands of the Salem Academy and College; Recommendations for the Artificial Regeneration of Longleaf Pine at Pinehurst; Act regulating the use of and for the Protection of Meridian Monuments and Standards of Measure at the several county-seats in North Carolina; list of Magnetic Declination at the county-seats, January 1, 1910; letter of Fish Commissioner of the United States Bureau of Fisheries relating to the conditions of the North Carolina fish industries; report of the Survey for the North Carolina Fish Commission referring to dutch or pound-net fishing in Albemarle and Croatan sounds and Chowan River, by Gilbert T. Rude, of the United States Coast and Geodetic Survey; Historical Sketch of the several North Carolina Geological Surveys, with list of publications of each.

Biennial Report, 1911-1912, Joseph Hyde Pratt, State Geologist, 1913. 8°, 118 pp. *Postage 7 cents.*

Administrative report, and contains reports on method of construction and estimate of cost of road improvement in Stantonsburg Township, Wilson County; report on road conditions in Lee County; report on preliminary location of section of Spartanburg-Hendersonville Highway between Tryon and Tuxedo; report of road work done by U. S. Office of Public Roads during biennial period; experiments with glutrin on the sand-clay road; report on Central Highway, giving Act establishing and report of trip over this Highway; suggested road legislation; report on the Asheville City watershed; report on the Struan property at Arden, Buncombe County; report on the woodlands on the farm of Dr. J. W. Kilgore, Iredell County; report on examination of the woodlands on the Berry place, Orange County; report on the forest property of Miss Julia A. Thorns, Asheboro, Randolph County; report on the examination of the forest lands of the Butters Lumber Company, Columbus County; proposed forestry legislation; swamp lands and drainage, giving drainage districts; suggested drainage legislation; proposed Fisheries Commission bill.

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